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ABSTRACT

This document contains lesson plans for a four-unit course in agriculture for sustainable development and is accompanied by a video tape and a booklet that discusses existing and future agricultural practices. Each unit of the document contains some or all of the following components: an introduction; objectives and competencies addressed; a list of equipment, supplies, references, and other resources; three or four learning activities; a question-and-answer game based on the format of the television game show "Jeopardy"; problem-solving techniques; illustrations of agricultural operations; material safety data sheet examples; and sample newspaper articles. The topics of the four units are as follows: (1) sustainable agriculture (investigation and analysis of agricultural practices as related to conservation tillage and best management practices); (2) innovative chemistry and conservation tillage (advantages and disadvantages of pesticide applications and the interrelationship of herbicide use with conservation tillage); (3) genetically improved plants (implications of genetically improved plants to our society and for agriculture on a global basis); and (4) Third World impact and global stability (the economic importance and interdependency of agriculture throughout the world). (MN)

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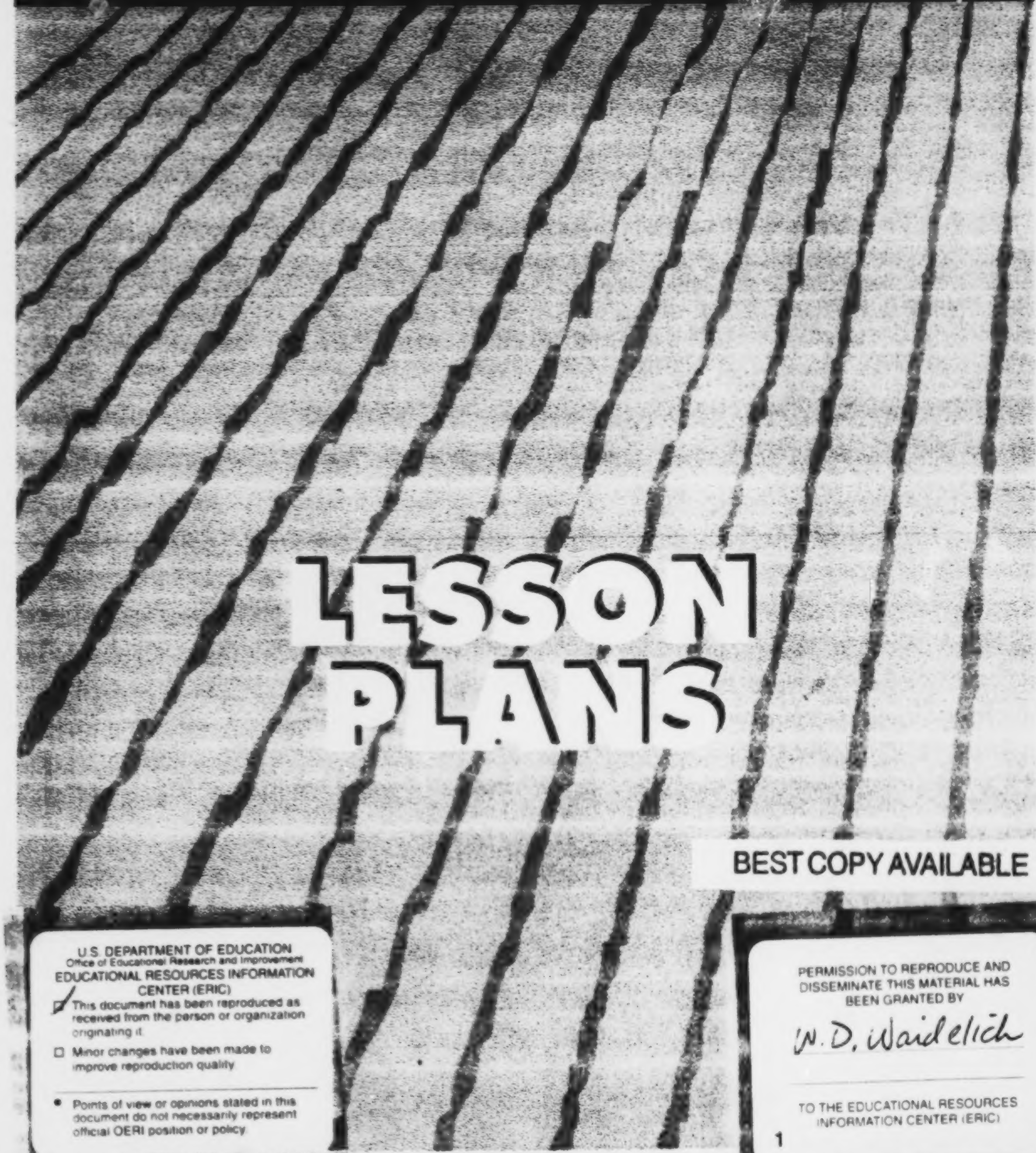
COMMON GROUND

AGRICULTURE FOR A SUSTAINABLE FUTURE



LESSON PLANS

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Common Ground:
Agriculture for a Sustainable Future

Lesson Plans

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1996

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We also gratefully acknowledge the educational value of the game show ***JEOPARDY!***, the format of which we used in this publication. "***JEOPARDY!***" is produced by Columbia TriStar Television, a Sony Pictures Entertainment Company, and is distributed worldwide by King World Productions, Inc.

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Program: **Common Ground: Agriculture for a Sustainable Future**
Unit 1: **Sustainable Agriculture**

Investigation and analysis of agricultural practices as related to conservation tillage and best management practices (BMPs)

Competency/Terminal Performance Objective

Given examples, assess current agricultural practices in four different regions of the U.S. and design for each a best management plan (BMP) which implements sustainable agriculture practices.

Competency Builders/Pupil (Learner) Performance Objectives

Define sustainable agriculture and recognize its importance in farming practices in the U.S. and on the global market.

Evaluate the importance of conservation tillage in controlling erosion; demonstrate measures to prevent or reduce erosion and moisture loss.

Describe environmental and economic trade-offs involved in making decisions about agricultural practices.

Make informed decisions based on current agricultural science information.

Integrate and utilize the technique of modeling through the use of hands-on experimentation.

Applied Academics Competencies

Communications
History
Mathematics
Science

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Equipment, Supplies, References, and Other Resources

Activity #1 - Jeopardy!-like Game

1. scissors
2. felt-tipped marker
3. Velcro dots or tape
4. 2 large poster boards (same size)
5. 2 buzzers or bells

Activity #2 - Conservation Tillage Experimental Design

1. 2 roasting pans or similar (same size)
2. 1 dried piece of sod same size as pan
3. bean seeds
4. water
5. spray bottle
6. newspaper
7. eyedropper
8. clear glass or plastic containers
9. mulch materials such as pine needles, straw, bark, etc.
10. apple corer
11. lettuce seeds (optional)

Activity #3 - Best Management Plan Design

- illustrations of agricultural operations in four regions of the U.S. (pages 16-19)

REFERENCES/RESOURCES

Environment Resource Guides on Non-point Source Pollution (grades 9-12), Air and Waste Management Association, P.O. Box 2861, Pittsburgh, PA 15230

Agriculture and the Environment, The 1991 Yearbook of Agriculture, U.S. Government Printing Office, Washington, DC

Conservation Tillage - video available from Ohio Agricultural Education Curriculum Materials Service, 254 Agricultural Administration Bldg., 2120 Fyffe Road, Columbus, OH 43210-1067

Managing Residue to Reduce Erosion - slide series available from Ohio Agricultural Education Curriculum Materials Service, 254 Agricultural Administration Bldg., 2120 Fyffe Rd, Columbus, OH 43210-1067

Situation

These activities are designed for students in grades 9-12.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
The activities can be done as stand-alone units or in succession to build data and information cumulatively. If done in succession, they set the stage for the final activity, which utilizes concepts and solutions arrived at in activities #1 and #2 and the problem-solving student worksheets. **Advance Preparation** Prepare the *Jeopardy!* board by cutting 30 3x5-inch windows spaced one inch apart for game categories and answers. Save the cutout windows to serve as flap covers for the answer portions. There will be 5 windows across the top for categories and an additional 5 windows below each of these for answers. Answers for each category will be designated point values of 10, 20, 30, 40 and 50. Attach the second poster board to the first with Velcro dots or tape. Tape together the answer sheets provided and slide between the two poster boards. Reattach the flaps over the answers by taping each across the top to serve as a hinge. Use the marking pen to designate point value on each of the answer flaps.	**ACTIVITY 1** *Jeopardy!-like Game* **Interest Approach** Pique the students' interest using the Dust Bowl of the 1920s and 1930s as an example. Discuss how poor farming techniques contributed to severe soil erosion and nutrient depletion, hampered further by poor economic times and drought conditions. Survey the students to find out what they think about today's farming techniques and where agriculture is headed in the future. **Teaching Procedure** ***Playing the game:*** Divide the students into 2 or 3 groups. Provide the person at the head of each line with the buzzer or bell. Flip a coin to determine which group makes the first selection. Open the flap selected to expose the answer. The first person to ring the buzzer gets to respond by providing a question for the revealed answer. (**Note:** In many cases, there may be more than one correct question to a given answer.) The first person with the correct question scores the value on the flap. A wrong question results in a deduction of the value on the flap. When all flaps are exposed, the highest score wins! *(continued)*

Directions for the Teacher

Extension

The game board can be used for other topics by simply replacing the category/answer sheets on pages 9 and 10 with new ones.

Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 1 *(continued)*

Key Terms

1. *Best Management Practices (BMPs)* - an engineered structure or management activity or combination of these that eliminates or reduces adverse environmental effects of pollutants.
2. *Conservation Tillage* - any tillage practice that involves less soil disturbance and retains more plant residue on the soil surface than with conventional tillage methods.
3. *Conventional Tillage* - standard method of preparing a seedbed by completely inverting the soil and incorporating the residue with a plow.
4. *Erosion* - wearing away of the earth's surface by running water, wind, ice or other geological agents; processes by which material is removed from the earth's surface.
5. *Groundwater* - water that infiltrates into the earth and is stored in the soil and rock below the earth's surface.
6. *Herbicide* - a chemical or biological agent that kills plants.
7. *Insecticide* - a chemical or biological agent that kills insect pests.
8. *Non-point source pollution (NPS)* - pollution that cannot be traced to a specific point because it comes from many individual places or a widespread area (e.g., urban and agricultural runoff).
9. *Pollution prevention* - the use of processes, practices or products that reduce or eliminate the generation of pollutants and wastes, including those that protect natural resources through conservation or more efficient use of resources.
10. *Row-cropping* - farming practice of planting crops in rows, usually between 24 and 42 inches wide; commonly used in growing corn, soybeans and cotton.

Directions for the Teacher

Based on the information learned from playing the *Jeopardy!* game and researching conservation tillage, activity #2 further stimulates students to design an experiment using a set box of common everyday materials. This experiment will show how conservation tillage prevents soil erosion and moisture loss.

Note:
Because of the variability in this experiment, you may find that different approaches are taken by each of the teams.

Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 2

Conservation Tillage Experimental Design

Interest Approach

Challenge the students by setting this up as a team competition to design the best model for teaching the concept of conservation tillage to a layperson. If possible, invite a guest lecturer to make a presentation to the class about agricultural practices common to your area. (Consider the Soil Conservation Service, Extension personnel from your local college or university, or government/private industry personnel specializing in agricultural areas.)

Teaching Procedure

Divide the class into 4 or 5 groups and challenge each group to set up a simple, cost-effective model of conservation tillage which can be used to demonstrate the concept. Have the students build this model and demonstrate the results. Provide each group with a supply of the materials on the equipment list. To judge the results, invite younger students (or even parents) to a demonstration of the model and devise measurements to ascertain their comprehension level for each of the experiments.

Provide the students with the following objective:

Design an experiment that demonstrates the benefits of conservation tillage in reducing soil erosion and water pollution.

Data Summary & Analysis

Observe and record the results of the planting techniques that demonstrate resource conservation vs. conventional tillage. When water (simulating rain) is applied to the model, more sediment should result from the conventional tillage method than from the conservation tillage method. Discuss how the resource conservation method may or may not work in different farming configurations or in different geographical areas.

(continued)

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 2 *(continued)*

Key Terms

1. *Best Management Practices (BMPs)* - an engineered structure or management activity or combination of these that eliminates or reduces adverse environmental effects of pollutants.
2. *Conservation Tillage* - any tillage practice that involves less soil disturbance and retains more plant residue on the soil surface than with conventional tillage methods.
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8. *Row-cropping* - farming practice of planting crops in rows, usually between 24 and 42 inches wide; commonly used in growing corn, soybeans and cotton.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
See pages 16-19.	**ACTIVITY 3** *Best Management Plan (BMP) Design* **Interest Approach** Set the stage by discussing agriculture around the nation and the environmental concerns associated with American agriculture. **Teaching Procedure** Divide students into four groups and assign each group one of the attached illustrations depicting a typical agricultural setting in one of four regions of the U.S. Have the students prepare a step-by-step, economically viable, best management practice plan that emphasizes soil conservation techniques and uses conservation tillage, crop rotation, contouring, runoff diversion, and other methods. What are the barriers to implementing this plan? How might they be overcome? Have the students develop a model demonstrating how they would assess the effectiveness of the BMP they develop. **Key Terms** 1. *Best Management Practices (BMPs)* - an engineered structure or management activity or combination of these that eliminates or reduces adverse environmental effects of pollutants. 2. *Conservation Tillage* - any tillage practice that involves less soil disturbance and retains more plant residue on the soil surface than with conventional tillage methods. 3. *Conventional Tillage* - standard method of preparing a seedbed by completely inverting the soil and incorporating the residue with a plow. 4. *Erosion* - wearing away of the earth's surface by running water, wind, ice or other geological agents; processes by which material is removed from the earth's surface. *(continued)*

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 3 *(continued)*

Key Terms *(continued)*

5. *Groundwater* - water that infiltrates into the earth and is stored in the soil and rock below the earth's surface.
6. *Non-point source pollution (NPS)* - pollution that cannot be traced to a specific point because it comes from many individual places or a widespread area (e.g., urban and agricultural runoff).
7. *Pollution prevention* - the use of processes, practices or products that reduce or eliminate the generation of pollutants and wastes, including those that protect natural resources through conservation or more efficient use of resources.
8. *Row-cropping* - farming practice of planting crops in rows, usually between 24 and 42 inches wide; commonly used in growing corn, soybeans and cotton.
9. *Contouring* - plowing sloped land by going around a hill instead of up and down to reduce erosion, control water flow, and increase moisture penetration.
10. *Herbicide* - a chemical or biological agent that kills plants.
11. *Insecticide* - a chemical or biological agent that kills insect pests.
12. *Runoff diversion* - construction of physical barriers such as dikes and ditches or vegetative buffer zones to slow the rate of surface water runoff.

JEOPARDY! ANSWERS

Tillage Systems	Regional Differences	It All Boils Down to Economics	Ag & the Environment	New Challenges for Conservation
The tillage system with at least 30% of soil surface covered by plant residue after planting.	The area of the U.S. with the largest acreage (34M acres) and the highest proportion of its cropland farmed with conservation tillage.	The farm program instituted in the 1930s that discourages many conservation tillage and crop rotation practices by keeping farmers from diversifying beyond certain crops (corn, cotton and wheat) with their high agrichemical requirements.	The most common contaminant of groundwater (according to US EPA); present in 52-57% of community and private wells nationwide.	This bill, passed in 1985, was aimed at preventing erosion on the nation's worst farmland.
The tillage system with soil left undisturbed before planting, which is completed in a narrow seedbed; weeds controlled with herbicides.	The two main considerations for the regional differences in how much conservation tillage is practiced.	The costs that farmers are not charged for, giving them little incentive to curtail activities that adversely impact the environment.	The law known as FIFRA, which regulates sale and use of pesticides, but does not specifically address pesticide pollution of water supplies.	Land areas comprising 14% of the farmland, on which almost 30% of U.S. agricultural production occurs; due to location, much of this farmland is lost each year to development.
The tillage system with soil left undisturbed before planting, which is completed in a seedbed prepared on a ridge; weeds controlled with herbicides and cultivation (ridges rebuilt).	The area of the U.S. where conservation tillage is a major advantage with winter-seeded grain, keeping soil temperatures in winter above the level of severe crop damage.	Two disincentives for adoption of more efficient irrigation systems.	The type of pollution that cannot be traced to a single source and is a major problem related to agricultural activity.	Kind of land subject to conservation compliance; comprises over 118 million acres and more than 25% of the nation's farmland.
The tillage system with soil left undisturbed before planting; tillage in row at planting time done with rototiller, in-row chisel, row cleaners, etc.; herbicides and cultivation used to control weeds.	Type of land slow to adopt conservation tillage because of concern that plant residue will retard water flow and cause differences in water coverage between upper and lower parts of the field.	Most Americans would be willing to pay 5-10% more for food with **this**.	In 1987, this state led the nation in agriculture and in the sale of 580M pounds of pesticide active ingredients.	The major problem caused by non-point pollution, with its unknown sources.
The tillage system with soil surface disturbed before planting; same equipment used as in conventional tillage (except for moldboard plow); weeds controlled by herbicides and cultivation.	The two major factors that determine the differences between agricultural regions of the U.S.	Three areas that are key decision variables for American consumers in their purchase of food.	Two of the three strategies for biological control that use parasites, predators, and pathogens to maintain pest populations at levels that do not cause unacceptable economic or aesthetic damage.	The group of plants considered specialized vegetation and used to combat wind and water erosion. About 78 varieties produced commercially; developed from germplasm of foreign origin.

JEOPARDY! QUESTIONS

Tillage Systems	**Regional Differences**	**It All Boils Down to Economics**	**Ag & the Environment**	**New Challenges for Conservation**
What is conservation tillage?	What is the Corn Belt?	What is the farm subsidy program?	What are nitrates?	What is the 1985 Farm Bill?
What is no-till?	What are the major crops grown and what are the soil and climatic conditions?	What are hidden costs or external costs ("externalities") associated with environmental degradation and non-point source pollution?	What is the Federal Insecticide, Fungicide and Rodenticide Act?	What are metropolitan areas or cities (urban fringe farmland)?
What is ridge-till?	What are the Northern Plains?	What are low prices for federal water supplies and lack of available startup funds?	What is non-point source pollution?	What is highly erodible land?
What is strip-till?	What is irrigated land?	What are reduced pesticide residues?	What is California?	What is degradation of water quality in our nation's streams, reservoirs and lakes?
What is mulch-till or reduced-till?	What are soil and climate?	What are safety, price, and quality?	What are conservation of natural enemies of pests; augmentation with natural enemies; and importation of natural enemies?	What are conservation plants (like crown vetch)?

• **Steps/Key Points** •
Problem-Solving Technique

Define the Problem

What is conservation tillage? How do soil erosion and moisture loss occur? What are the factors needed to ensure that conservation tillage techniques are successful?

What to Do (Steps)	How to Do It (Key Points)

Decision/Recommendation

Students should conclude that conservation tillage is an acceptable and effective technique for growing crops. Because of its low impact approach, soil erosion and moisture loss are minimized, thus ensuring a more productive growing environment. Two factors which help to ensure the success of conservation tillage are proper equipment and training and appropriate use of herbicides (with application timing being crucial).

• Situation-to-Be-Improved •

Problem-Solving Technique

Define the Problem

Taking into account topography, soil type, climate, common cultural practices, and cost, determine what factors are necessary to optimize the use of conservation tillage. Are there cases where conservation tillage is not a viable alternative?

Characteristics to Be Considered	What	Why	Current Situation	Recommendations

Decision/Recommendation

Students should conclude that level land that is well drained, with deep soil and no physical impediments like outcropping rock, is best suited for conservation tillage. Also, not all topography, soil types and drainage, or climatic conditions lend themselves to conservation tillage as a viable alternative. Land not suitable for conservation tillage includes shallow soil, severely sloping land, overgrazed land, and very arid regions where irrigation is necessary. Areas with high insect infestation (such as cotton in areas with large pink bollwarm concentrations) are also unsuitable for conservation tillage.

• Possibilities - Factors •
Problem-Solving Technique

Define the Problem

What are the environmental and economic trade-offs involved in the decision to use the sustainable agriculture approach? Determine the environmental implications of a well-designed and implemented agricultural management plan (involving such topics as non-point source pollution, groundwater contamination, wildlife protection, etc.).

Factors to Consider	**Possibilities (Possible Solutions)**			

Decision/Recommendation

Students may conclude that initial costs for existing farms will be higher due to requirements for new equipment; additional herbicide applications; and setting up buffer zones, runoff basins and trenches to divert runoff. Environmental trade-offs are 1) greater quantities of herbicides applied to the soil in exchange for reduced soil erosion; and, with last year's crop residue on the ground, 2) the need for close monitoring of insect populations. A well-designed BMP should minimize groundwater contamination and non-point source pollution as well as reduce the likelihood of off-site contamination of streams and waterways that directly impact wildlife.

• Forked Road •
Problem-Solving Technique

Define the Problem

In a highly competitive global market, what options does the American farmer have to increase his/her profitability? Given your choices, what options would you choose? Why?

Factors to Consider	Choices	
	Choice One	Choice Two

Decision/Recommendation

Conservation tillage may actually reduce the cost of overall crop production and lead to increased yields, making farmers more competitive on the global market. Students should appreciate the factors involved in practicing conservation tillage and understand their overall effect on farm profitability.

To increase their profitability, farmers must either increase their output (yields) or increase the quality of their product so that it commands a higher price. Also, they must make the most effective use of equipment, pesticides, and fertilizers to make the best use of their land.

• Effect-Cause •

Problem-Solving Technique

Define the Problem

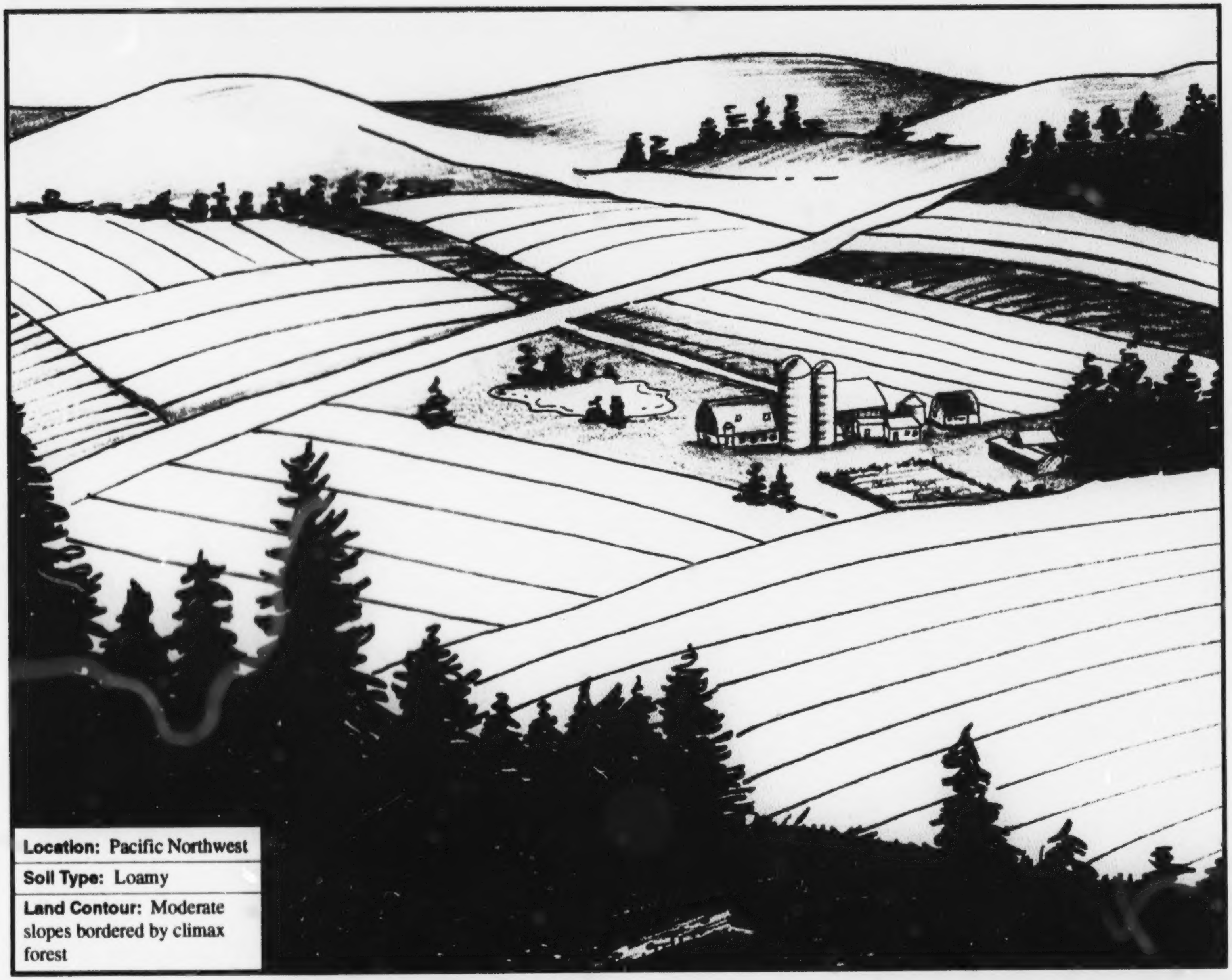
A farmer has practiced conservation tillage for 10 years now and has found that the crop yields have decreased over the past 5 years by 2% in year 6, 2.8% in year 7, and 3% each in years 8, 9, and 10. If the farmer averaged 97 bushels/acre of corn in the first 5 years, what were the yields for each of the past 5 years? What information do you need in order to determine what the problem is and to provide solutions to the farmer's dilemma?

Possible Causes	Related Facts	Accept/Reject Cause

Decision/Recommendation

With no method stipulated, students may choose either the simple or compound method to calculate the reduced yield figures. This could be utilized as a point of discussion (for mathematics) for simple vs. compound interest scenarios as well as calculating percentages.

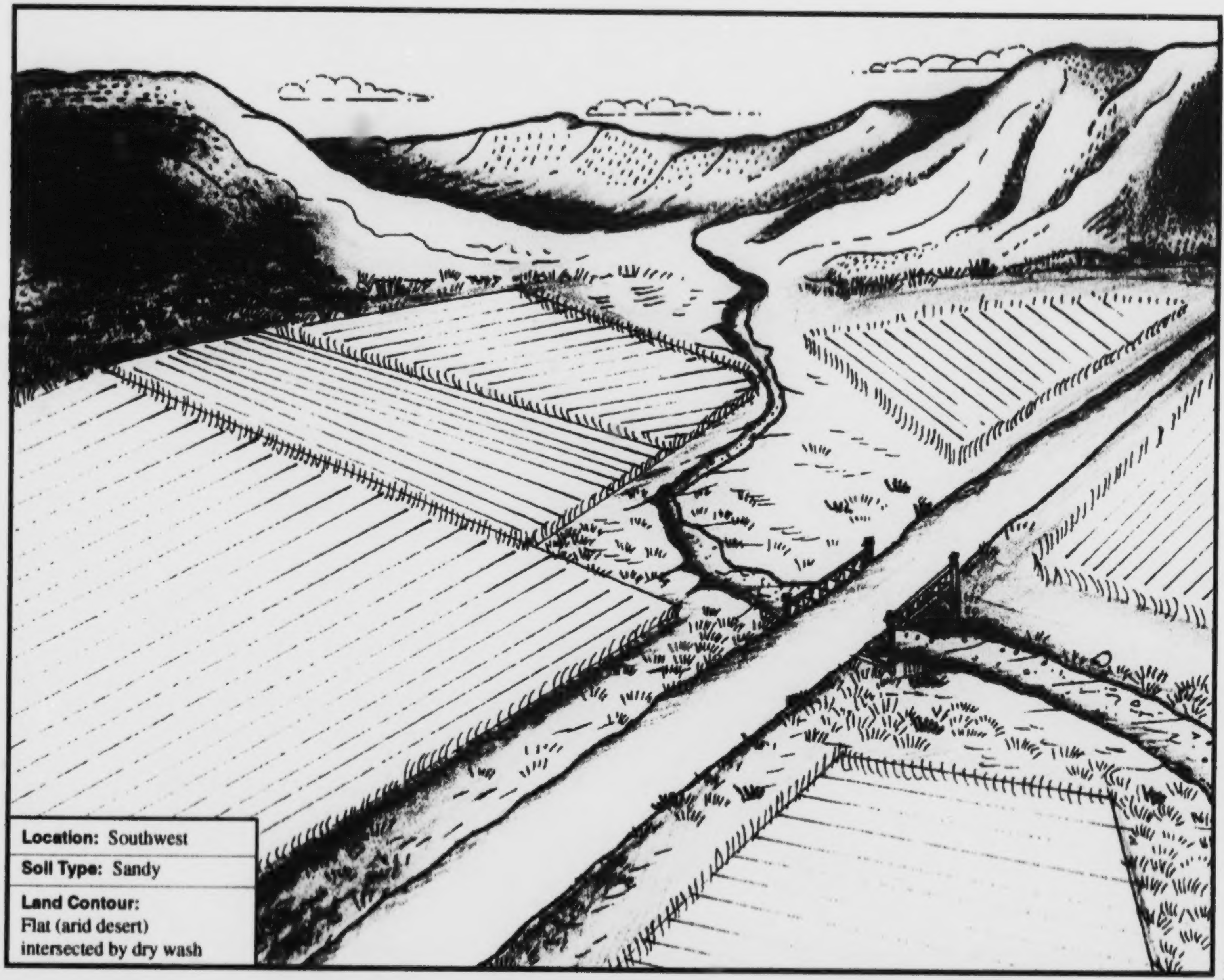
The farmer's common cultural practices, involving equipment, planting, and pesticide application, are needed as well as references to climate, topography, soil type, etc. to determine possible solutions to the problem.



Location: Pacific Northwest

Soil Type: Loamy

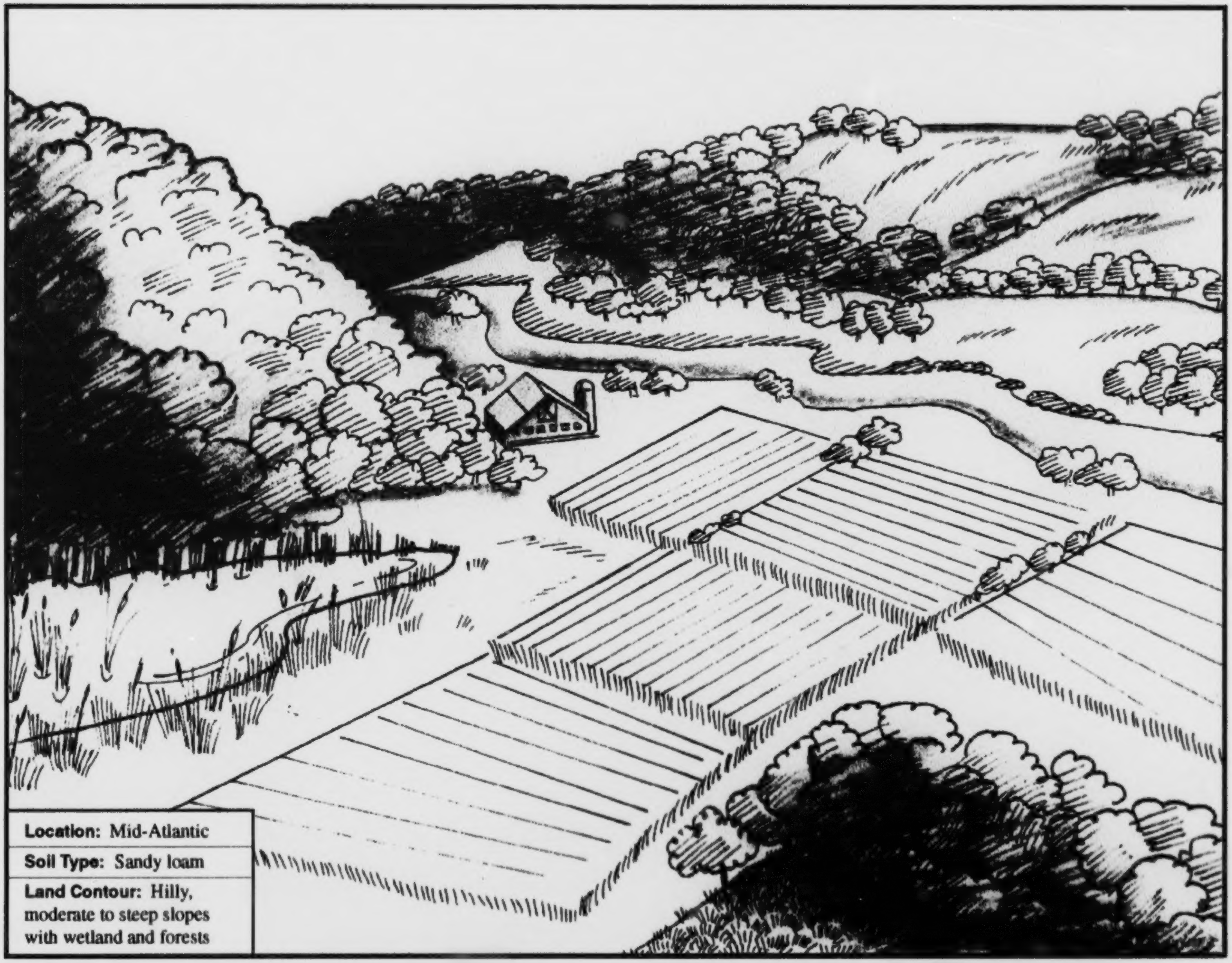
Land Contour: Moderate slopes bordered by climax forest

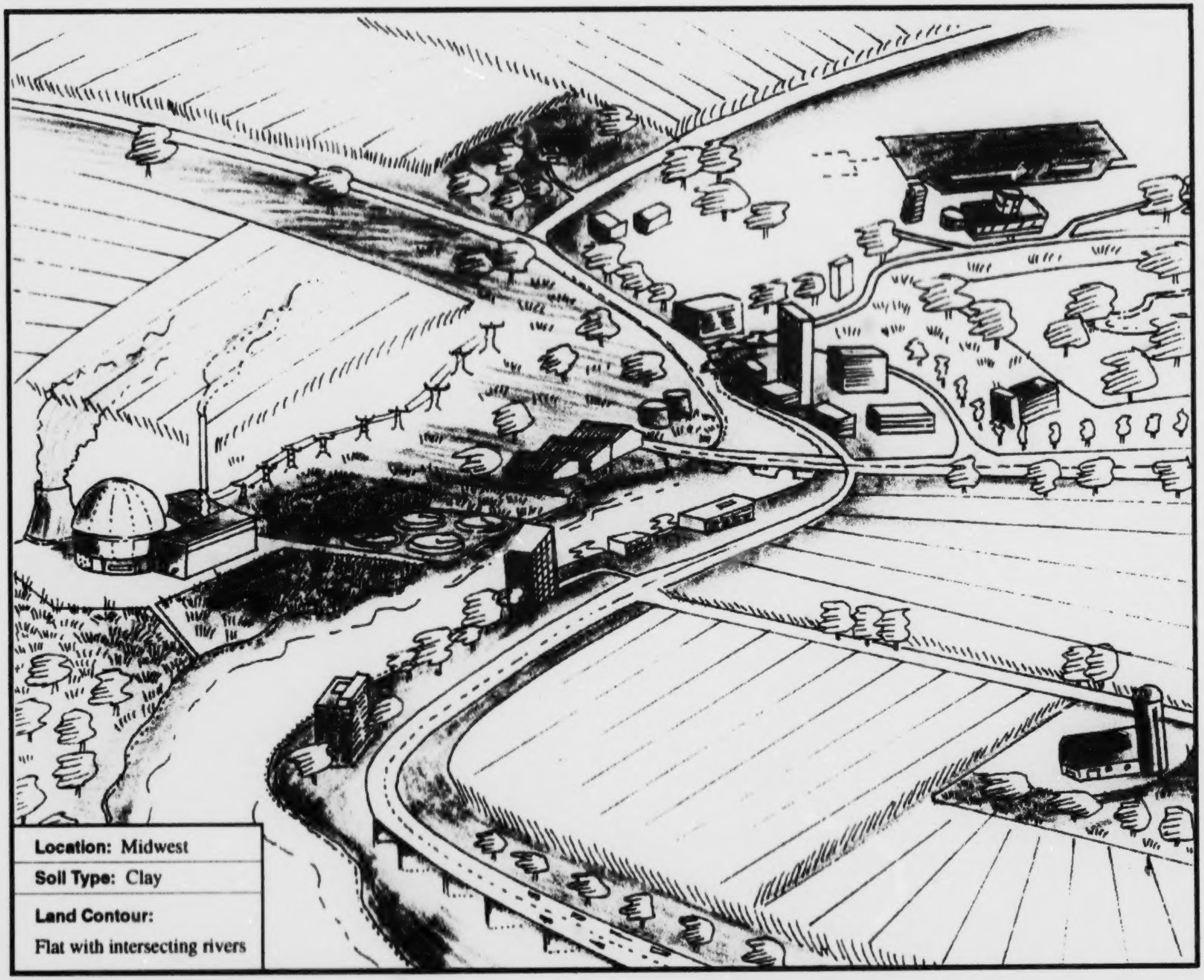


Location: Southwest

Soil Type: Sandy

Land Contour:
Flat (arid desert)
intersected by dry wash


Location: Mid-Atlantic
Soil Type: Sandy loam
Land Contour: Hilly, moderate to steep slopes with wetland and forests



Location: Midwest

Soil Type: Clay

Land Contour:

Flat with intersecting rivers

Program: Common Ground: Agriculture for a Sustainable Future
Unit 2: Innovative Chemistry and Conservation Tillage

Advantages and disadvantages of pesticide applications and the interrelationship of herbicide use with conservation tillage

Competency/Terminal Performance Objective

Recognize the advantages and disadvantages of pesticide application and evaluate the farmer's options for controlling insects, weeds, and plant diseases.

Competency Builders/Pupil (Learner) Performance Objectives

Define the term pesticide. Describe different types and why they are used.

Recognize the advantages and disadvantages of pesticide application and the interrelationship of herbicide use with conservation tillage.

Evaluate mechanical, biological, and chemical control of plant pests with regard to economics, the environment, health, safety, and effectiveness.

Collect and analyze samples of disease damage on plants. Identify and dry mount common weed samples; identify and mount common insect specimens.

List information found on a pesticide label.

Develop an awareness of some of the methods used in commercial decision-making for pesticide manufacture. Practice skills in the evaluation of evidence and the use of information and data in making decisions.

Understand and be able to discuss the uses for a Material Safety Data Sheet (MSDS) for a selected pesticide.

Applied Academics Competencies

Communications
History
Mathematics
Science

Equipment, Supplies, References, and Other Resources

Activity #1 - Pesticide Registration Exercise

- student worksheets (attached)

Activity #2 - Identification and Analysis of Common Agricultural Pests

For insects:

1. killing jars
2. labels
3. mounting pins
4. cardboard or Styrofoam mounting boards
5. vinegar
6. baking soda

For weeds:

1. 2 glass plates (for pressing specimens flat)
2. cardboard or Styrofoam mounting boards
3. glue

For diseases:

- cardboard or Styrofoam mounting boards for leaves, etc. which show disease effects

Activity #3 - Evaluation of an MSDS

- Material Safety Data Sheets (MSDS) (attached)

Activity #4 - Jeopardy!-like Game

1. scissors
2. felt-tipped marker
3. Velcro dots or tape
4. 2 large poster boards (same size)
5. 2 buzzers or bells

REFERENCES/RESOURCES

The following resource materials are available from Ohio Agricultural Education Curriculum Materials Service, 254 Agricultural Administration Bldg., The Ohio State University, 2120 Fyffe Road, Columbus, OH 43210-1067:

Agronomy Identification Series - slide series on the identification of crop plants & seeds; weed plants & seeds; and field crop & stored grain insects

Herbicide Mode of Action and Injury Symptoms - a manual that provides information on soil-applied and post-emergence herbicide activity in plants, herbicide selectivity, and herbicide resistance

Weed Plants - spiral-bound book of color photographs and descriptions of 40 common weed plants

Insect Pests of Field Crops - a bulletin that provides up-to-date information for insect pest control in field crops

Integrated Pest Management I: Ecology, Crops and Pests - student activity guide with three major activities looking at ecosystems, pest populations, and how pests integrate with one another

Situation

These activities are designed for students in grades 9-12.

Directions for the Teacher

It is valuable to precede this activity with a discussion of what pesticides are, their advantages and disadvantages, and why they are used. This activity is best if conducted in small groups of four or five, with an appointed group recorder. At the end of the exercise, a large group session can be held to compare results. Alternatively, groups could be asked to design posters advertising one of the pesticides by incorporating information from the activity.

Advance Preparation

It would be useful to have samples of pest-damaged plants and examples of commercial pesticides available for showing the class along with some sample pesticide labels.

Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 1

Pesticide Registration Exercise

Interest Approach

Explain the concerns surrounding pest management. Pests destroy approximately one-third of the world's food crops annually, making pest management a worldwide problem. Discuss how in ancient times the Romans combated insects in their stored grains by mixing in silica dust. Today road dust is mixed with the grain in some cultures to protect against grain weevils. The dust acts as an abrasive, causing damage to the insect's exoskeleton, which can ultimately lead to death. Ask students to make a quick list of some of the properties of a good pesticide.

Teaching Procedure

Divide the class into small groups of 4 or 5 students. Provide each group with a copy of the pesticide registration activity (pages 7-10). Allow the students one class period to work on the activity and summarize their results. Have the recorder for each group present the results in the next class period. Open each topic to discussion when all the results have been presented. Analyze the results of each group and have the students defend their positions. Provide a summary from all groups and discuss the results.

Key Terms

1. *Conservation Tillage* - any tillage practice that involves less soil disturbance and retains more plant residue on the soil surface than with conventional tillage methods.
2. *Fungicide* - an agent that kills fungi.
3. *Herbicide* - chemical or biological agent that kills plants.
4. *Insecticide* - chemical or biological agent that kills insect pests.
5. *Material Safety Data Sheet (MSDS)* - required by law, this data sheet lists the physical and chemical characteristics of a compound along with health and safety data. Disposal information is sometimes included.
6. *Pesticide* - a chemical or biological agent that kills plant or animal pests. Herbicides, insecticides, fungicides, and rodenticides are all pesticides.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
If your school is located where common agricultural weeds, insects and diseases are easy to find, use the collection procedure. If they are not readily accessible, substitute a "paper exercise," challenging the students to bring in pictures of common agricultural weeds, insects and diseases for discussion.	**ACTIVITY 2** *Identification and Analysis of Common Agricultural Pests* **Interest Approach** Talk about the organic approach to farming, what our lives would be like (society, economics) without the use of pesticides. Invite a professional from a local agricultural industry (agrichemical, horticulture, agribusiness, farm) to speak to the class about common practices and pesticide use. **Teaching Procedure** Divide the class into two groups. Assign to one group the task of finding 15 weeds and 4 diseases; to the other group, 15 insects and 4 diseases. Place the insects collected into a "killing jar," which has a small amount of baking soda in the bottom. Add vinegar to the baking soda to kill the insects. Have each group mount its collection as appropriate. **Key Terms** 1. *Conservation Tillage* - any tillage practice that involves less soil disturbance and retains more plant residue on the soil surface than with conventional tillage methods. 2. *Fungicide* - an agent that kills fungi. 3. *Herbicide* - chemical or biological agent that kills plants. 4. *Insecticide* - chemical or biological agent that kills insect pests. 5. *Material Safety Data Sheet (MSDS)* - required by law, this data sheet lists the physical and chemical characteristics of a compound along with health and safety data. Disposal information is sometimes included. 6. *Pesticide* - a chemical or biological agent that kills plant or animal pests. Herbicides, insecticides, fungicides and rodenticides are all pesticides.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
Make copies of the Material Safety Data Sheets (pages 18-27) for each student in the class.	**ACTIVITY 3** *Evaluation of a Material Safety Data Sheet (MSDS)* **Interest Approach** Have students discuss some of the chemicals commonly used in the home and some of the characteristics and health and safety information that they think might be included on an MSDS. **Teaching Procedure** Have the students compare the Material Safety Data Sheet of a household chemical to that of a pesticide. What are the similarities? What are the differences? Which chemicals are the most toxic? Why? **Key Terms** 1. *Conservation Tillage* - any tillage practice that involves less soil disturbance and retains more plant residue on the soil surface than with conventional tillage methods. 2. *Fungicide* - an agent that kills fungi. 3. *Herbicide* - chemical or biological agent that kills plants. 4. *Insecticide* - chemical or biological agent that kills insect pests. 5. *Material Safety Data Sheet (MSDS)* - required by law, this data sheet lists the physical and chemical characteristics of a compound along with health and safety data. Disposal information is sometimes included. 6. *Pesticide* - a chemical or biological agent that kills plant or animal pests. Herbicides, insecticides, fungicides and rodenticides are all pesticides.

Directions for the Teacher

If the *Jeopardy!*-like board was already constructed in Unit 1, Activity #1, skip the advance preparation procedures and insert the category/answer template located on pages 11-12 in this unit.

Advance Preparation

Prepare the *Jeopardy!* board by cutting 30 3x5-inch windows spaced one inch apart for game categories and answers. Save the cutout windows to serve as flap covers for the answer portions. There will be 5 windows across the top for categories and an additional 5 windows below each of these for answers. Answers for each category will be designated point values of 10, 20, 30, 40 and 50. Attach the second poster board to the first with Velcro dots or tape. Tape together the answer sheets provided and slide between the two poster boards. Reattach the flaps over the answers by taping each across the top to serve as a hinge. Use the marking pen to designate point value on each of the answer flaps.

Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 4

Jeopardy!-like Game

Interest Approach

Pique the students' interest by discussing the widespread use of DDT in the 1950s and 1960s. For several decades, DDT was a very effective insecticide, used throughout the world. However, now many countries, including the U.S., have banned the use of DDT. Scientific studies conducted over several decades have determined that DDT affects the life cycle of birds, fish, and some beneficial insects. Today, the pesticides used target specific pests and are considerably safer to humans and wildlife. They also degrade faster in the environment.

Teaching Procedure

Playing the game: Divide the students into 2 or 3 groups. Provide the person at the head of each line with the buzzer or bell. Flip a coin to determine which group makes the first selection. Open the flap selected to expose the answer. The first person to ring the buzzer gets to respond by providing a question for the revealed answer. (**Note:** In many cases, there may be more than one correct question to a given answer.) The first person with the correct question scores the value on the flap. A wrong question results in a deduction of the value on the flap. When all flaps are exposed, the highest score wins!

Key Terms

1. *Conservation Tillage* - any tillage practice that involves less soil disturbance and retains more plant residue on the soil surface than with conventional tillage methods.
2. *Fungicide* - an agent that kills fungi.
3. *Herbicide* - chemical or biological agent that kills plants.
4. *Insecticide* - chemical or biological agent that kills insect pests.
5. *Material Safety Data Sheet (MSDS)* - required by law, this data sheet lists the physical and chemical characteristics of a compound along with health and safety data. Disposal information is sometimes included.
6. *Pesticide* - a chemical or biological agent that kills plant or animal pests. Herbicides, insecticides, fungicides and rodenticides are all pesticides.

Pesticide Registration Exercise

Background

Before pesticides can be sold and used commercially, they must go through rigorous testing over several years. It takes 7 to 10 years to develop a typical chemical pesticide at a cost of approximately $80M. This testing includes the following determinations:

- ○ Food products from crops treated with the pesticide are safe to eat.
- ○ The pesticide is safe to use when handled according to the directions on the label.
- ○ The environment and wildlife are not harmed by using the pesticide.
- ○ The pesticide does not significantly damage the crop.
- ○ The pesticide is effective. That is, when used properly, it does what it claims to do. (This testing, called *efficacy*, is not currently required by the US EPA, but has been required in the past. It could well be reinstated as a requirement in the future.)

Damage by arthropods (insects, spiders and mites) is a major contributor to crop losses and decreased quality of agricultural products. Based on past history, it is predicted that arthropod species will increase in number by about 11 each year and that 7 of those will become significant pests.

In this hypothetical situation, we are dealing with a new arthropod species named *Cornelius devastata* or CD. It causes widespread devastation in crops of the brassica family (e.g., cabbage, cauliflower, and broccoli). This new pest is a voracious eater; at sufficient population levels, it can completely decimate the crop.

In this exercise, you will wear the hat of an official of the US EPA. You have been asked to evaluate three new chemical pesticides which have been developed by the agrichemical industry sector to control CD damage in broccoli. For the past four years, broccoli and cauliflower growers have requested a Section 18 permit to use non-labeled pesticides on their crops to prevent widespread crop devastation by this insect. They have had limited success with using these other pesticides. The three pesticides to be evaluated are CD-B-Gone, Go-CD, and CD-OFF.

CD-B-Gone is a very effective pesticide; it kills 98% of the CD insects in areas where it is sprayed. It is extremely poisonous to humans and animals. A small amount of it is systemically taken up into the plant, so crop damage from the chemical ranges between 5 and 10%.

Go-CD kills 90% of the CD insects in the treated area. It is not poisonous to humans, but can kill up to 4% of the earthworms in the treated area. The crop is unaffected by this chemical. It is recommended that 10 days elapse between use of the product on the crop and harvesting the crop. Birds find the dead insects unappetizing and do not eat them.

CD-OFF kills only 50% of the CD insects when sprayed; therefore, frequent applications are required to get the population under control. This pesticide is harmful to wildlife, but it does not affect the crop.

(continued)

Pesticide Registration Exercise *(page 2)*

Types of Registration

There are three types of "registrations" which you can give a pesticide. The fourth option is to refuse registration. Here are the definitions for each type.

1. Experimental Use Permit (EUP) for research trials - The pesticide can be used on a limited basis only for research field trials with farmers (small quantities, small plot work).
2. Emergency Use - Section 18 - This is issued only under "emergency" conditions for use on crops for which the pesticide is not labeled or in states or regions where its use may not be permitted. The farmer must demonstrate that he/she will experience significant economic loss if the pest is not brought under control.
3. Full Registration - When all the criteria above are met, the US EPA issues this registration. The product may now be sold and used commercially.
4. Refuse a Registration - If the product does not meet the specified guidelines or does not include sufficient data, the registration request may be refused.

Questions

○ Which registration would you give each of the pesticides mentioned on the preceding page? Give reasons for your answers.

○ What additional information do you need (which was not specified) to validate your decisions?

○ In order to grant an Emergency Use (Section 18) permit, what data would you need from the farmer to make this decision?

○ If you decide to refuse registration for any of the products, what is the basis for your refusal?

Field Trials

Under a research trial experimental use permit, plant field trials are normally carried out in a replicated block fashion to increase accuracy and validity of the trial. This statistical design, called randomized complete block design (RCBD), takes variations in field conditions (soil, drainage, etc.) into account, removing some of the variability by averaging replicates and then comparing the data against a check or control (untreated plot).

A sample field may look like the one shown on the next page in Figure 1. **Note:** This illustration is done specifically for this exercise. Since the three products being considered were probably created by different agrichemical companies, each of the products would have been compared against the control and a standard (the chemical that is currently being used commercially for controlling CD, if one exists). All the products being considered, then, would not be in the same trial unless each of the agrichemical companies had provided a university researcher with the experimental compounds to

(continued)

Pesticide Registration Exercise *(page 3)*

place in a cooperator or university trial. In addition, actual field trials would have been conducted to look at factors such as application timing, effectiveness of different pesticide rates (dosages), effect of type of application, and so on. Insecticide trials are particularly difficult to conduct since they are directly dependent upon adequate insect population pressure to obtain accurate data. In this field trial, there are four replicates and the products are randomized within each replicate. The number of dead CDs per square foot is noted in parentheses ( ) under each pesticide in each plot.

FIGURE 1

Replicate 1		**Replicate 2**	
CD-B-Gone (11)	Go-CD (9)	CD-OFF (9)	Control (0)
Control (0)	CD-OFF (6)	Go-CD (16)	CD-B-Gone (17)
CD-OFF (12)	CD-B-Gone (22)	CD-OFF (5)	Control (0)
Go-CD (20)	Control (0)	Go-CD (9)	CD-B-Gone (10)
Replicate 3		**Replicate 4**	

Precount of CDs prior to application revealed an average population of 16 CDs per square foot. Once the pesticides were applied, dead CDs per square foot numbered from 5 to 22.

Next, set up a data chart with the following format and place in it each of the values from the replicates in Figure 1. Calculate an average for each of the pesticides.

Data Chart

Pesticide	**Replicate 1**	**Replicate 2**	**Replicate 3**	**Replicate 4**	**Average**
CD-B-Gone					
Go-CD					
CD-OFF					
Control					

Look at the data closely. What reason is plausible for the high numbers of dead CDs in Replicate 3?

In the chart on the next page are given the crop damage (tolerance) ratings, which indicate damaged plants per square foot. These were obtained from the above field trial. Assume that the crop population is relatively consistent at 4 broccoli plants/square yard.

(continued)

Pesticide Registration Exercise *(page 4)*

Number of Plants Damaged per sq ft

Pesticide	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Average
CD-B-Gone	1	1	2	0	
Go-CD	0	0	1	0	
CD-OFF	1	0	0	0	
Control	0	0	0	0	

Calculate the averages for crop tolerance.

Questions

○ Do the data for each of the products support the crop tolerance statements made? Why? Or why not?

○ What other kinds of trials or tests could you conduct?

○ Is it important to know the method by which the pesticides kill or incapacitate the CD insect? Why would you need to know this information?

Data Summary and Analysis

Students should come to the following conclusions:

✓ ***CD-B-Gone*** should be refused a registration. Due to its extreme toxicity to humans and animals, it does not meet U.S. EPA toxicological parameters to allow additional testing and/or registration.

✓ ***Go-CD*** provides effective control with minimal risk to humans and wildlife, though it may affect a small percentage of the earthworm population. Students may want to provide the manufacturer with full trial registration, assuming that all toxicological, wildlife and environmental data have been collected and analyzed. If an emergency situation arises, this compound would be the best choice for the special emergency provision.

✓ ***CD-OFF*** is only 50% effective, and the information available states that it is harmful to wildlife. Students may want to issue a research trial registration to collect additional data and to validate the preliminary findings. It would be helpful to know what wildlife is affected by the pesticide and how.

JEOPARDY! ANSWERS

A Matter of Control	Pests, Pests, & More Pests	Adapt or Die	Pesticide Paraphernalia	The R&D Cycle
Three categories of methods that farmers use to control pests.	The problem that causes annual crop losses estimated at $1.5 to $2 billion.	The interesting adaptive strategy shown by weeds that throughout history have adapted to agricultural practices.	The first place to find information on application timing, utilization on specific crops, human health & safety, and disposal instructions for a commercial pesticide.	Trials conducted nationwide to test a new product for efficacy and crop tolerance.
The management technique known as IPM that is ecologically based and environmentally conscious in controlling plant pests.	The problem that costs farmers approximately $5 billion annually to control on farms and in range lands, forests and waterways.	The important characteristics of weeds that mimic agricultural crops.	The sheet known as MSDS, required by law on all chemical compounds, that provides health and safety, disposal, & other necessary information.	Once required by US EPA, the indication based on data that a given pesticide has the capability to control the targeted pests.
The crucial factor in the effectiveness of a pesticide in controlling a pest.	The estimated percentage of loss in crop value due to weeds - nearly $16 billion per year.	The weed that is the most serious rival to rice and the most difficult to differentiate from it.	The classification, with specific guidelines, that a chemical must receive before it is approved for sale commercially.	Measurement of the amount of damage to a crop from a given pesticide.
A group of compounds that includes insecticides, herbicides, fungicides and rodenticides.	Three traditional approaches to managing pest problems.	The class of organisms that are most resistant to synthetic chemical agents.	The special classification of a pesticide that permits its emergency use for a specific crop.	The type of extensive testing of a pesticide over several years, that measures the levels of safety to humans and wildlife.
The techniques used to predict pest occurrence.	The trait of pests that continually complicates pest management.	The pesticide now outlawed but once widely used; insects rapidly developed resistance to it.	Two of the reasons that a new pesticide could be refused registration.	The preliminary check of large numbers of compounds to determine whether they are potential pesticide candidates.

JEOPARDY! QUESTIONS

A Matter of Control	Pests, Pests, & More Pests	Adapt or Die	Pesticide Paraphernalia	The R&D Cycle
What are mechanical, chemical and biological methods?	What are viral diseases?	What is mimicry?	What is the label?	What are plant field trials?
What is Integrated Pest Management?	What are weeds?	What are seeds that ripen by harvest time; seeds that remain on their stems during harvest; and seeds with shape or density similar to that of the crop seed?	What is the Material Safety Data Sheet?	What is efficacy?
What is application timing?	What is 10-20% of the total crop value?	What is barnyard grass?	What is full registration?	What is crop tolerance?
What are pesticides?	What are traditional breeding techniques to develop new crop varieties, cultural practices, and chemical applications?	What are insects?	What is an Emergency Use (Section 18) permit?	What is toxicological testing?
What are crop/pest models and environmental modeling?	What is plant pests' adaptation to new management techniques?	What is DDT?	What are toxic to humans and wildlife; unsafe in residues on food; causing significant crop damage?	What is primary screening?

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• Steps/Key Points •
Problem-Solving Technique

Define the Problem

Your company, Innovative Chemicals, Inc., has just signed a contract with a pharmaceutical firm which gives them permission to test a group of 1,000 chemical compounds for potential use as new pesticides. How would you test the new compounds to see if they are potential candidates for agricultural chemicals? Of the thousands of compounds that agrichemical companies test for each year, only 2 or 3 will meet the criteria necessary for commercial use. What are these criteria? How can you test for them?

What to Do (Steps)	How to Do It (Key Points)

Decision/Recommendation

New compounds are put through several screening processes to determine whether they meet the tests to be viable agricultural chemicals. Preliminary screening tests for toxicity automatically eliminate most of the compounds. Next, the compounds are tested for herbicide, insecticide or fungicide activity at various dosages. Effective compounds are then moved into the next phase and tested for environmental effects and effects on wildlife. With all these data assimilated, a decision is made to move a compound into the "Development" phase and to conduct field testing of the compound. Important criteria for testing include toxicity, environmental impact, and dosages needed. (If too high a dosage is necessary, the compound may become too toxic, or its production costs might increase to levels where it is not competitive with other products.)

• Situation-to-Be-Improved •
Problem-Solving Technique

Define the Problem

What are the advantages and disadvantages of pesticide application? What is the interrelationship of herbicide use with conservation tillage? Compare the economics, environmental effect, health & safety issues, and effectiveness of chemical control vs. mechanical or biological control. Based on your comparisons, which method would you recommend? Why? Are there situations where a combination of these methods would be appropriate?

Characteristics to Be Considered	What	Why	Current Situation	Recommendations

Decision/Recommendation

Advantages include higher yields, better quality, and higher price. Disadvantages include potential environmental problems, such as groundwater contamination, non-point source pollution, chemical residues in the food supply, potential health hazards to farm personnel and wildlife, and expense. Generally, a higher volume of herbicide is required per acre when conservation tillage practices are used because of the lack of cultivation to control weeds.

Control Methods	Economics	Environmental Effects	Health & Safety	Effectiveness *
Chemical	9	8	9	9
Mechanical	5	4	3	7
Biological	8	2	1	5

Based on a scale of 1 to 10, where 10 is the highest impact and 1 is the lowest.

* Effectiveness rating is based on applying the pesticide at the appropriate time in the life cycle of the weed, insect or disease.

• Possibilities - Factors •

Problem-Solving Technique

Define the Problem

Inorganic insecticides are some of the most toxic pesticides on the market today. Each year brings the US EPA closer to eliminating these products from the market. But insect problems can mean a serious loss of yield to the farmer. Developing new organic products that are still able to kill or maim insect populations will be crucial. What characteristics must be taken into account when creating a new organic insecticide?

Factors to Consider	Possibilities (Possible Solutions)			

Decision/Recommendation

Some of the factors that should be taken into account are biodegradability, timing of application, mechanism of insecticide delivery, type of application, new technologies (making the plant immune to the insect through a "natural" insecticide created by biotechnology), overwintering (climatic conditions), and others.

• Forked Road •
Problem-Solving Technique

Define the Problem

What pesticides are labeled for use on the following crops?– wheat, corn, soybeans and cotton. Create a hypothetical weed, insect or disease problem for each crop. Provide two options for products you would use to solve the problem. Defend your choice by using information about the product, land use, region of the country, climate, soil type, costs, etc.

Factors to Consider	Choices	
	Choice One	Choice Two

Decision/Recommendation

Students need to take into account all the above information in selecting an appropriate option. Normally there are several products on the market that can be used for particular weeds, insects or diseases. Each product must be applied according to label specifications; its effectiveness when applied is directly tied to the life cycle stage of the weed, insect or disease. If the "window of opportunity" for applying a compound is missed, the product may be totally ineffective in dealing with the pest. Students should take into account the stage of the crop, weed, insect or disease in selecting the most effective option.

• Effect-Cause •
Problem-Solving Technique

Define the Problem

A cotton farmer in Arizona noticed that the cotton plants on the outer rows of a field bordering a pistachio grove were exhibiting stress. Two weeks later, upon examination, the farmer saw a sticky white substance on the leaves and cotton bolls. Although an insecticide was sprayed on the field at that time, damage continued and resulted in reduced yields and poor seed quality. What are some of the possible causes? What steps should the farmer have taken to deal with this problem?

This particular field was part of a seed increase contract for a major cottonseed company. The following year, how do you think farmers were affected when they bought seed from that area?

Possible Causes	Related Facts	Accept/Reject Cause

Decision/Recommendation

Possible causes include insect or disease damage (in this case, whitefly damage). The farmer lost yields by not examining the cotton on a regular basis for insect population growth (especially when the crop was bordered by another crop that attracts insects) and by not addressing the problem at the time in the insect life cycle when an insecticide would have controlled the population growth. The farmer lost money due to reduced yields and poor quality seed.

Since this problem occurred on many seed increase fields that year, the quality and viability of cottonseed sold to farmers the following year was inferior. This resulted in reduced plant stands, lower yields, and numerous lawsuits.

Date: 8/25/94

MATERIAL SAFETY DATA SHEET

SECTION 1

The NutraSweet Company
1751 Lake Cook Road
Deerfield, IL 60015-5239

Emergency Telephone Numbers
USA - 708/940-9800
CANADA - 800/267-9475

Product Names: Equal Powder

Formula: Mixture

SECTION 2

COMPOSITION/INFORMATION ON INGREDIENTS:

Ingredients /CAS Number	Exposure Limits	Concentration (%)
Aspartame 22839-47-0	5 mg/m^3 (respirable) * 10 mg/m^3 (total) *	92 - 97
maltodextrin 9050-36-6	5 mg/m^3 (respirable) *	3 - 8

* - Materials that do not have specific exposure limits are regulated as "nuisance" dusts at these limits.

SECTION 3

HAZARDS IDENTIFICATION:

Potential Effects:	No adverse effects known.
Human Effects and Symptoms of Overexposure:	None known.
Acute Inhalation:	No known effects
Chronic Inhalation:	No known long term effects
Acute Skin Contact:	No known effects
Chronic Skin Contact:	No known long term effects
Acute Eye Contact:	No known effects
Chronic Eye Contact:	No known long term effects
Carcinogenicity:	NTP: NO; IARC: NO; OSHA: NO

Medical Conditions Aggravated by Exposure:
Ingestion: Phenylketonuria
Inhalation: none known

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Date: 8/25/94

Product Name: Equal Powder

SECTION 4

FIRST AID MEASURES:
Eyes: Flush eyes for 15 minutes with water.
Skin: Wash skin with water.
Inhalation: Remove from exposure. Seek attention of physician.
Ingestion: None needed, product is a food additive.

SECTION 5

FIRE FIGHTING MEASURES:
Flash Point: Not applicable
Extinguishing Media: Water
Special Fire Fighting Procedures: None

SECTION 6

ACCIDENTAL RELEASE MEASURES:
Spill or Leak Procedures: Vacuum or sweep up and place in containers for disposal. Residue can be washed down and sent to the sanitary sewer.

SECTION 7

HANDLING AND STORAGE:
Storage Temperature (Min./Max.): 15 °C/ 30 °C
Shelf Life: 5 years
Special Sensitivity: Can pick up undesirable odors.
Handling and Storage Precautions:
Store between 35 and 60 % Relative Humidity.
Avoid high heat and store under dry conditions.
Keep container tightly closed and inner bag sealed.
Keep away for sources of odors.

SECTION 8

EXPOSURE CONTROLS/PERSONAL PROTECTION:
Eye Protection: With normal handling, none needed
Skin Protection: None required
Respiratory/Ventilation: None required with normal handling. If excessive dusting occurs, a nuisance dust respirator can be used with proper procedures.
Exposure Limits: 5 mg/m^3 respirable dust, 10 mg/m^3 total dust

Product Name: Equal Powder

SECTION 9

PHYSICAL AND CHEMICAL PROPERTIES:

Physical Form:	Solid; fine granules
Color/Odor:	White/None
Boiling Point:	Not applicable
Dust Class:	ST-2 (severe dust explosion potential)
Minimum Explosion Concentration:	0.110 oz/cu ft
Kst:	206 bar-m/sec
Minimum Spark Ignition Energy:	less than 0.20 joules
Autoignition Temperature:	Not applicable
Melt/Freeze Point:	240 - 245 °C by observation. When measured with a Differential Scanning Calorimeter there are endotherms at 121, 170 and 245 °C.
pH:	Not applicable
Solubility in Water:	1%
Specific Gravity:	1.3
Bulk Density:	0.50 - 0.70 g/cc
% Volatile by Weight:	0
Vapor Pressure/Density:	Not applicable/Not applicable
Molecular Weight:	mixture

SECTION 10

REACTIVITY:

Stability:	Stable
Hazardous Polymerization:	Will not occur
Incompatibilities:	None
Decomposition Products:	CO_2, CO, NO_x

SECTION 11

TOXICOLOGICAL INFORMATION: A vast data base exists regarding the safety of aspartame in man. Oral doses of 75 mg/kg/day to human subjects for 6 months did not produce any clinical signs. LD_{50} ORAL: >5000 mg/kg (rat) (Practically non-toxic). Inhalation exposure of male and female rhesus monkeys to aspartame at concentrations up to 16 mg/m^3, 6 hours per day for 14 consecutive days, did not produce any treatment related effects. Acceptable Daily Intake (ADI) approved by FDA is 50 mg/Kg/Day.

SECTION 12

ECOLOGICAL INFORMATION: Biodegradable, non-regulated material

SECTION 13

DISPOSAL CONSIDERATIONS: Waste disposal method: Send to sanitary landfill following local, state and federal regulations.

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Date: 8/25/94

Product Name: Equal Powder

SECTION 14

TRANSPORTATION INFORMATION:

D.O.T. Shipping Name: None
Technical Shipping Name: Aspartame
D.O.T. Hazardous Class: Not applicable
U.N./N.A. Number: Not applicable
Product RQ (lb): Not applicable
D.O.T. Label: Not applicable
D.O.T. Placard: None
Product Label: Equal powder

SECTION 15

REGULATORY INFORMATION:

OSHA Status: Not specifically regulated.
TSCA Status: Registered
CERCLA Reportable Quantity: None
SARA Title III:
- Section 302 Extremely Hazardous Substances: No
- Section 311/312 Hazard Categories: No
- Section 313 Toxic Chemicals: No

RCRA Status: Not listed
State Regulatory Information: Not regulated except by the FDA as a food additive

SECTION 16

OTHER INFORMATION:

Reason for Issue: New
Approval Date: 8/25/94
Supersedes Date: New

Although the information and recommendations set forth herein (hereinafter "Information") are presented in good faith and believed to be correct as of the date hereof, The NutraSweet Company makes no representations as to the completeness or accuracy thereof. Information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for the purposes prior to use. In no event will The NutraSweet Company be responsible for damages of any nature whatsoever resulting from the use of or reliance upon information. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OR TO THE PRODUCT TO WHICH INFORMATION REFERS.

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MONSANTO PRODUCT NAME

ROUNDUP® ULTRA Herbicide

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: ROUNDUP® ULTRA herbicide

Synonyms: MON 65005

EPA Reg. No.: 524-475

Company ID: Monsanto Company
800 North Lindbergh
St. Louis, MO 63167, U.S.A.

Phone #s: Emergency Phone Number (call collect): (314) 694-4000
Non-Emergency Information: 1-800-332-3111

Revisions: Sections containing a revision or new information are marked with a ♣

MSDS Number: S00012770 **Date: November, 1995** **Supersedes: None**

2. COMPOSITION INFORMATION ON INGREDIENTS

Chemical Ingredients: *Active Ingredient:* Glyphosate, N-(phosphonomethyl) glycine, in the form of its isopropylamine salt .... 41.0 %
Inert Ingredients: .... 59.0 %
100.0%

Component	CAS Reg No	wt %
Glyphosate, isopropylamine salt	38641-94-0	41.0%

No Hazardous Chemicals Under OSHA Hazard Communication Standard (29 CFR §1910.1200).
No components subject to the reporting requirements of SARA §313.

See Section 8 for exposure limits.

3. HAZARDS IDENTIFICATION

Emergency Overview:

Appearance & Odor: Clear, viscous amber-colored solution

Warning Statements: Keep out of reach of children.
CAUTION !
CAUSES EYE IRRITATION
REFORMULATION IS PROHIBITED
SEE INDIVIDUAL CONTAINER LABEL FOR REPACKAGING LIMITATIONS

Potential Adverse Health Effects:

Likely Routes of Exposure: Skin contact and inhalation

Eye Contact: ROUNDUP® ULTRA herbicide may cause pain, redness and tearing based on toxicity studies.

Skin Contact: ROUNDUP® ULTRA herbicide is no more than slightly toxic and no more than slightly irritating based on toxicity studies.

Ingestion: ROUNDUP® ULTRA herbicide is no more than slightly toxic based on toxicity studies. No significant adverse health effects are expected to develop if only small amounts (less than a mouthful) are swallowed. Ingestion of similar formulations has been reported to produce gastrointestinal discomfort with irritation of the mouth, nausea, vomiting and diarrhea. Oral ingestion of large quantities of one similar product has been reported to result in hypotension and lung edema.

Inhalation: ROUNDUP® ULTRA herbicide is no more than slightly toxic if inhaled based on toxicity studies.

4. FIRST AID MEASURES

If In Eyes: Flush with plenty of water. Get medical attention if irritation persists.

NOTE: For additional human emergency first aid or treatment guidance, call collect, anytime, day or night (314) 694-4000.

5. FIRE FIGHTING MEASURES

Flash Point: >200°F **Method:** Pensky-Martens

Auto Ignition Temperature: Not determined

Extinguishing Media: Water spray, foam, dry chemical, CO_2, or any class B extinguishing agent.

Special Fire Fighting Procedures: Firefighters and others that may be exposed to vapors, mists, or products of combustion should wear full protective clothing and self-contained breathing apparatus. Equipment should be thoroughly cleaned after use.

Unusual Fire or Explosion Hazards: None

6. ACCIDENTAL RELEASE MEASURES

Observe all protection and safety precautions when cleaning up spills - See Exposure Controls/Personal Protection, Section 8.

Small Spills: For a spill less than one gallon on floor or other impervious surface, soak up with towels or other absorbent material and discard in the trash. Clean the spill area with soap and water and rinse the area thoroughly.

Large Liquid Spills on the floor or other impervious surface should be contained or diked and then absorbed with attapulgite, bentonite or other absorbent clays. Collect the contaminated absorbent, place in a metal drum and dispose of in accordance with the instructions provided under Disposal, Section 13 of this MSDS. Thoroughly scrub floor or other impervious surface with a strong industrial detergent and rinse with water.

Large spills that soak into the ground should be dug up, placed in metal drums and disposed of in accordance with instructions provided under DISPOSAL, Section 13 of this MSDS. Contact appropriate state agency when considering a land spreading disposal option.

Leaking containers should be separated from non-leakers and either the container or its contents transferred to a drum or other non-leaking container and disposed of in accordance with instructions provided under DISPOSAL, Section 13 of this MSDS. Any recovered spilled liquid should be similarly collected and disposed of.

7. HANDLING AND STORAGE

Handling:
- Avoid contact with eyes or clothing.
- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

- Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark.
- Do not contaminate water when disposing of equipment washwaters.

Storage:

- Do not contaminate water, foodstuffs, feed or seed by storage or disposal.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Personal Protective Equipment:

Eye Protection: Workers handling the packaged concentrate should wear chemical safety goggles to prevent eye contact during mixing/transfer operations or other activities where there is potential for eye contact with the concentrated product. The wearing of goggles is not required during use of this product in accordance with label instruction.

Skin Protection: Wear appropriate protective clothing to prevent skin contact. Applicators and other handlers must wear long-sleeved shirt, long pants, shoes plus socks. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

Respiratory Protection: *For Handling the Concentrated Product:* Avoid breathing vapor or mist. This product concentrate is not likely to pose an airborne exposure concern during manufacture or packaging. In the event of abnormal exposure conditions, use NIOSH/MSHA approved equipment. In work situations where an air-purifying respirator is appropriate to be used, use of a full face respirator equipped with purifying elements for protection against organic vapor and dust/mist approved for pesticides is recommended. Use cartridges with NIOSH/MSHA approval number TC-23C or canister with NIOSH/MSHA approval number TC-14G. Full facepiece replaces the need for chemical goggles. Observe respirator use limitations specified by the manufacturers. Respiratory protection programs must comply with 29 CFR 1910.134.

For Use of Product in accordance with label instructions: Respirators are not required for use of ROUNDUP® ULTRA herbicide in accordance with label instructions.

Ventilation: No special precautions are recommended.

Exposure Guidelines:

Exposure Limits	OSHA PEL	ACGIH TLV
ROUNDUP® ULTRA	None established	None established

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	clear, viscous amber-colored solution
Odor:	practically odorless to slight amine-like odor
Ph:	4.99 (1% solution)
Specific Gravity:	1.17 (Water = 1)

Note: These physical data are typical values based on material tested but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specification items.

10. STABILITY AND REACTIVITY

Chemical Stability:	Stable for at least 5 years under normal conditions of warehouse storage.
Conditions to Avoid:	None

Incompatibility with Other Materials: Spray solutions of this product should be mixed, stored or applied using only stainless steel, aluminum, fiberglass, plastic or plastic-lined containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

Hazardous Decomposition Products: None

Hazardous Polymerization: Does not occur. This product can react with caustic (basic) materials to liberate heat. This is not a polymerization but rather a chemical neutralization in an acid base reaction.

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11. TOXICOLOGICAL INFORMATION

Data from laboratory studies conducted by Monsanto with ROUNDUP® ULTRA herbicide are summarized below:

Single exposure (acute) studies indicate:

Oral -	Rat LD_{50} - >5,000 mg/kg; FIFRA Category IV
Dermal -	Rat LD_{50} - >5,000 mg/kg; FIFRA Category IV
Inhalation -	Rat LC_{50} (4-hr. exp.) - 4.2 mg/l; FIFRA Category IV; Not DOT poisonous
Eye Irritation -	Rabbit; moderately irritating.; all animals free of irritation by day 7, FIFRA Category III
Skin Irritation -	Rabbit (4-hr. exp.); slightly irritating; PII - 0.63/8.0, all animals free of irritation by day 7, FIFRA Category IV

No skin allergy was observed in guinea pigs following repeated skin exposure.

COMPONENTS

Data from laboratory studies conducted by Monsanto and from the scientific literature on components of ROUNDUP® ULTRA herbicide:

Isopropylamine Salt of Glyphosate

Data from studies with a formulation comprised of 62% isopropylamine salt of glyphosate (MON 0139) indicate the following:

In repeat dosing studies (6-month), dogs fed MON 0139 exhibited slight body weight changes. Following repeated skin exposure (3-week) to MON 0139, skin irritation was the primary effect in rabbits.

Additional toxicity information is available on glyphosate, the active herbicidal ingredient of MON 0139. Following repeated exposures (90-days) to glyphosate in their feed, decreased weight gains were noted at the highest test level in mice, while no treatment-related effects occurred in rats. Following repeated skin exposure (3 weeks) to glyphosate, slight skin irritation was the primary effect observed in rabbits. No skin allergy was observed in guinea pigs following repeated skin exposure. There was no evidence of effects on the nervous system, including delayed effects in chickens (repeat oral doses) or cholinesterase inhibition in rats (single oral doses). Reduced body weight gain and effects on liver tissues were observed with long-term (2-year) feeding of glyphosate to mice at high-dose levels. Reduced body weight gain and eye changes were observed at the high-dose level in one long-term (2 year) feeding study with rats, while no treatment-related effects occurred in a second study. No adverse effects were observed in feeding studies with dogs. Glyphosate did not produce tumors in any of these studies. **Based on the results from the chronic studies, EPA has classified glyphosate in category E (evidence of non-carcinogenicity for humans).** No birth defects were noted in rats and rabbits given glyphosate orally during pregnancy, even at amounts which produced adverse effects on the mothers. Glyphosate was fed continuously to rats at very high dose levels for 2 successive generations. Toxicity was reported in offspring from the high dose, a level which also produced adverse effects on the mothers. In a 3 generation study conducted at lower dose levels, no effects were seen on the ability of male or female rats to reproduce. Glyphosate has produced no genetic changes in a variety of standard tests using animals and animal or bacterial cells.

12. ECOLOGICAL INFORMATION

Aquatic and Avian studies with this product have not been conducted at this time. However, an extensive database of studies exists for the active ingredient glyphosate. These studies indicate that glyphosate ranges from practically non-toxic to slightly toxic in a variety of aquatic and avian species. For glyphosate MSDS or additional information, contact Monsanto at 1-800-332-3111.

13. DISPOSAL CONSIDERATIONS

Wastes resulting from the use of this product that cannot be used or chemically reprocessed should be disposed of in a landfill approved for pesticide disposal or in accordance with applicable Federal, state or local procedures.

Emptied container retains vapor and product residue. Observe all labeled safeguards until container is cleaned, reconditioned or destroyed.

14. TRANSPORT INFORMATION

Follow the precautions indicated in the Handling and Storage Section, Section 7 of this MSDS.

DOT Proper Shipping Name:	Not Applicable
DOT Hazard Class/I.D. No.:	Not Applicable
DOT Label:	Not Applicable
U.S. Surface Freight Classification:	Weed killing compound, N.O.I.B.N.

15. REGULATORY INFORMATION

SARA Hazard Notification:

Hazard Categories Under Criteria of SARA Title III Rules (40 CFR Part 370): Immediate

Section 313 Toxic Chemical(s): Not Applicable

Hazardous Chemicals Under OSHA Hazard Communication Standard (29 CFR §1910.1200): None

Reportable Quantity (RQ) under U.S. CERCLA: Not Applicable

TSCA Inventory: All components are on the US EPA's TSCA Inventory List

16. OTHER

Reasons for revision: New Product

This Material Safety Data Sheet (MSDS) serves different purposes than and DOES NOT REPLACE OR MODIFY THE EPA-APPROVED PRODUCT LABELING (attached to and accompanying the product container). This MSDS provides important health, safety, and environmental information for employers, employees, emergency responders and others handling large quantities of the product in activities generally other than product use, while the labeling provides that information specifically for product use in the ordinary course.

Use, storage and disposal of pesticide products are regulated by the EPA under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) through the product labeling, and all necessary and appropriate precautionary, use, storage, and disposal information is set forth on that labeling. It is a violation of federal law to use a pesticide product in any manner not prescribed on the EPA-approved label.

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Program: **Common Ground: Agriculture for a Sustainable Future**
Unit 3: **Genetically Improved Plants**

Implications of genetically improved plants to our society and for agriculture on a global basis

Competency/Terminal Performance Objective

Evaluate the impact of plant biotechnology techniques, recognize benefits and risks, and appraise the implications for agriculture on a global basis.

Competency Builders/Pupil (Learner) Performance Objectives

Identify plant biotechnology techniques.

Discuss the implications of genetically improved plants to our society.

Create a plan to introduce genetically improved plants in four major areas of the world.

Evaluate the economic, environmental and social aspects of introducing genetically improved plants in the U.S. and throughout the world.

Analyze media reports on plant biotechnology. Draw conclusions.

Appraise the field of plant biotechnology and make informed decisions about perceived risks and benefits.

Applied Academics Competencies

Communications
History
Mathematics
Science

Equipment, Supplies, References, and Other Resources

Activity #1 - Introduction of Genetically Improved Plants on a Global Basis

- world map

Activity #2 - Debating the Pros and Cons of Agricultural Biotechnology

- sample newspaper article

Activity #3 - Plant Tissue Culture Exercise

- plant tissue culture kit
  Available from your local educational equipment supplier or
  Ward's Natural Science Est., Inc.
  5100 West Henrietta Road
  P.O. Box 92912
  Rochester, NY 14692-9012

Activity #4 - Jeopardy!-like Game

1. scissors
2. felt-tipped marker
3. Velcro dots or tape
4. 2 large poster boards (same size)
5. 2 buzzers or bells

REFERENCES/RESOURCES

A New Technological Era for American Agriculture - U.S. Congress, Office of Technology Assessment, OTA-F-474, U.S. Government Printing Office, Washington, DC August 1992

A Guide to Biotechnology in Crop Production - North Carolina Cooperative Extension Service, North Carolina State University, P.O. Box 7602, Raleigh, NC 27695 Bulletin #AG-482

The following resource materials are available from Ohio Agricultural Education Curriculum Materials Service, 254 Agricultural Administration Bldg., The Ohio State University, 2120 Fyffe Road, Columbus, OH 43210-1067:

Introduction to Plant Biotechnology - introductory student manual containing descriptions, applications, discussion of impact, and job opportunities

Biotechnology in Agriculture - manual containing 6 instructional units dealing with microbial biotechnology, genetics and biotechnology in plant and animal science. Teacher guide also available

Biotechnology: A Science Tool for the Future - video giving an excellent overview of biotechnology as a tool for the advancement of science

Situation

These activities are designed for students in grades 9-12.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
Provide a world map for identification of the countries selected for this activity.	**ACTIVITY 1** *Introduction of Genetically Improved Plants on a Global Basis* **Interest Approach** Have students brainstorm to determine factors which would influence the introduction of genetically improved plants around the world. Each group should select a recorder and a reporter. Each reporter should report back to the class at the end of the brainstorming session. The teacher can record the responses on a chalkboard or overhead. Some of the answers may include land availability, planting/growing/harvesting seasons, soil type, topography, climate, economics, environment, and political and legal issues. The teacher may need to help the students draw out more abstract ideas such as culture, traditions, government policies, etc. When the list has been compiled, challenge students to research the countries they have chosen to obtain information about each of the factors cited. *(continued)*

Directions for the Teacher

Have each group present its findings to the class. To ensure that all students participate, divide up the factors and have each student in each of the groups present a portion of the group's findings.

Have the class collate the information from the research. Encourage class discussion with questions such as:

"Are there similarities between countries or regions of the world?"

"What are the economic, environmental and social impacts of introducing genetically improved plants to each of the countries researched?"

Extension

Invite a speaker from private industry, government, or a local university to talk about agricultural biotechnology and what research is currently being done.

Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 1 *(continued)*

Teaching Procedure

Divide the class into four groups. Assign one of the following country categories to each group. Have each group choose three countries from their assigned category for special focus.

Categories:

1. Industrialized Countries – countries with advanced infrastructure and high level of sophistication within local businesses. Includes most of the Western World - the European Community and North America - and some parts of Asia.
2. Middle Income Producing Countries – countries with primarily a natural resource- or agriculture-based economy. Includes newly industrialized economies of Southeast Asia and South and Central America. This sector has the fastest economic growth in the global economy.
3. Major Oil Exporting Countries – countries that are major oil producers, depending on the price of crude oil for their economic stability. Includes the oil-rich nations of the Middle East.
4. Less-Developed Countries – countries that depend on agriculture and natural resources to provide national income. Includes primarily Third World countries that lack the economic and environmental infrastructure to support widespread industrial growth.

Key Terms

1. *Biotechnology* – the application of biological processes to the production of materials for use in agriculture, medicine and industry.
2. *DNA (deoxyribonucleic acid)* – the complex chemical molecule containing hereditary information that is passed from parent to offspring.
3. *Gene* – a unit of heredity composed of DNA.
4. *Genetic engineering* – alteration of the characters of an organism by inserting genes from another organism into its DNA. Methods used are referred to collectively as recombinant DNA technology.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
The purpose of this activity is to provide a forum to debate the pros and cons of agricultural biotechnology. Students will need to research information to support their team's position. A sample article for use is included on pages 16 and 17.	**ACTIVITY 2** *Debating the Pros and Cons of Agricultural Biotechnology* **Interest Approach** To introduce what the public perception is of agricultural biotechnology and the risks and benefits of this science, give a short historical summary of American agriculture - past and present. Technological innovation has played a significant role in transforming American agriculture in the past and again promises major impacts on the U.S. food production and processing industries. The transition from horsepower to mechanical power (1920-1950) boosted the productive capacity of agriculture even as farm labor requirements decreased dramatically. From 1950 to 1980 agricultural productivity increased further as chemical fertilizers, feed additives and pesticides increased yields and helped farmers control pests and disease. Biotechnology and advanced computer systems now are ushering American agriculture into a new technological era. These technologies have the potential to increase U.S. agricultural productivity and competitiveness, enhance the environment, and improve food safety and quality. Today, the public is increasingly questioning whether technological change is always good or needed. New concerns are being voiced about the safety of the food supply, the environment, and the changing structure of agriculture. These issues, as well as declining public confidence in institutions in general, create an atmosphere in which agricultural biotechnology may not be readily approved for commercial use or adopted by industry. Lack of public acceptance could prevent some technologies from being used even if they are approved by regulatory agencies. *(continued)*

Directions for the Teacher	**Teaching Procedures: Interest Approach/Teaching Methods**
	ACTIVITY 2 *(continued)* **Teaching Procedure** Divide the class into two teams. Have each team appoint a team leader and a spokesperson. Flip a coin to determine the *pro* group and the *con* group. All team members should use local libraries, newspaper articles, magazines, TV broadcasts, company literature, computer databases, etc. to find articles and data to support their team's position. At the same time, they will be expanding their general knowledge of the subject. Some of the questions for the students to consider are: 1. What are the ethical concerns regarding agricultural biotechnology or genetic engineering? What are the risks? What are the benefits? 2. What data does the public need in order to draw educated conclusions about biotechnology? 3. Should the government be involved in creating laws regarding biotechnology? If yes, how? If no, why not? 4. What interrelationships will be affected by the new products and technology? What are the societal implications? 5. What are the implications if the U.S. fails to keep up with other countries in biotechnology?

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
Have a plant tissue culture kit available.	**ACTIVITY 3** *Plant Tissue Culture Exercise* **Background** Plant tissue culture is the technique of growing a whole plant from a single engineered cell or piece of plant tissue. This is very useful for scientists because it means that thousands of identical plants (clones) can be grown from the cell of a single plant. The parent plant selected has the desired genetic traits (for example, herbicide resistance, insect or disease resistance, heat or drought resistance, ripening alterations, flavors, textures, nutritional value, etc.). This process can be used for a number of vegetables, including carrots and potatoes, as well as for ornamental plants such as orchids. **Interest Approach** Have students brainstorm what the future will be like if the techniques of agricultural biotechnology provide plants that can withstand high or low temperatures, drought, and insects and disease. **Teaching Procedure** This activity requires the use of a plant tissue culture kit. The kits are available in two sizes: for demonstration (for 1 or 2) and for classroom use (up to 20). The exercise will span several weeks and will require specified observation activities (data collection/analysis).

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
If the *Jeopardy!*-like board was already constructed in Unit 1, Activity #1, skip the advance preparation procedures and insert the category/answer template located on pages 9-10 in this unit.	**ACTIVITY 4** *Jeopardy!-like Game* **Interest Approach** Pique the students' interest by discussing public perceptions of biotechnology. Ask students to present information they have heard about biotechnology and what they feel is fact or fiction.
Advance Preparation Prepare the *Jeopardy!* board by cutting 30 3x5-inch windows spaced one inch apart for game categories and answers. Save the cutout windows to serve as flap covers for the answer portions. There will be 5 windows across the top for categories and an additional 5 windows below each of these for answers. Answers for each category will be designated point values of 10, 20, 30, 40 and 50. Attach the second poster board to the first with Velcro dots or tape. Tape together the answer sheets provided and slide between the two poster boards. Reattach the flaps over the answers by taping each across the top to serve as a hinge. Use the marking pen to designate point value on each of the answer flaps.	**Teaching Procedure** ***Playing the game:*** Divide the students into 2 or 3 groups and provide the person at the head of each line with the buzzer or bell. Flip a coin to determine which group makes the first selection. Open the flap selected to expose the answer. The first person to ring the buzzer gets to respond by providing a question for the revealed answer. (**Note:** In many cases, there may be more than one correct question to a given answer.) The first person with the correct question scores the value on the flap. A wrong question results in a deduction of the value on the flap. When all flaps are exposed, the highest score wins!

JEOPARDY! ANSWERS

The Ancients	Plants for the Future	Potpourri	Biotechnology Techniques	The Media & the Public
The organisms that were used to make beer as early as 6000 B.C. in Sumerian and Babylonian times.	Bacteria that have a symbiotic relationship with leguminous plants such as soybeans, peas and peanuts. They eliminate the need for adding fertilizer.	The "new" plant formed by joining together protoplasts from potato and tomato plants; further clarifies how plants function and how they can be improved.	A specialized piece of equipment that is used to shoot high-velocity microprojectiles coated with DNA into a plant.	The pesticide residue scare in 1989 that received high media attention and negatively impacted consumer perceptions.
The milk-preservation product made by lactic acid bacteria in ancient China.	The bacteria with the gene for a toxin that has been successfully cloned and introduced into crops to protect them from caterpillar damage.	A mold grown in large quantities, dried, and specially prepared as nutritious natural food; it yields myco-protein – 45% protein, 13% fat, and high fiber content.	The technique used to rapidly clone large numbers of plants after a gene has been inserted.	Three of the specific food safety concerns of consumers.
The process used as early as 1400 A.D. in distilling grain into a variety of spirits.	The product, created from fermentation of sugar cane juice in Brazil, that has reduced the country's reliance on fossil fuels.	During this milling process, Swedish scientists have invented a way of using the waste to grow single cell protein (SCP), used for animal feed.	A specialized technology used to inactivate selected genes in a plant; (e.g., it is used to prevent softening in tomatoes.)	Term for the chance of loss or harm, with high or low occurrence and with varying severity, duration and timing.
A major beneficial discovery made by Alexander Fleming in 1928 - an early biotechnology contribution.	The two amino acids in corn that improve its nutritional value when their amounts are increased.	Three food products that contain common microbes that we eat every day.	Four major transgenetic crops that have been produced in the U.S.	Type of food the average consumer thinks is more likely to contain pesticide residue than is processed food.
Type of sanitation system based on microbial activity. Before its use, in the early 1900s, there were major outbreaks of disease in overcrowded industrial cities.	Three adverse environmental conditions against which agronomists are working as they develop ways to harden plants.	Geographical area where biotechnology may help provide food to keep people from massive starvation in frequently-occurring drought and heat conditions.	Name for genetically-engineered varieties of soybeans, corn and cotton that are not damaged by commercial weed control application.	Area that both industry and government must address to increase public confidence in new technology.

JEOPARDY! QUESTIONS

The Ancients	Plants for the Future	Potpourri	Biotechnology Techniques	The Media & the Public
What is yeast?	What are nitrogen-fixing bacteria of the genus *Rhizobium?*	What is the pomato plant?	What is a particle gun?	What is the Alar scare?
What is yogurt?	What is B.t. or *Bacillus thuringiensis?*	What is fusarium mold?	What is plant tissue culture?	What are pesticide residues, antibiotics & hormones, nitrites, irradiation, additives & preservatives, artificial colors, tampering, handling, improper processing, natural toxins, and bacteria?
What is fermentation?	What is fuel alcohol?	What is paper-making?	What is antisense technology?	What is risk?
What is penicillin?	What are lysine and trytophan?	What are yeast, mushrooms, malt extracts, cheese, bread, yogurt?	What are cotton, rice, soybeans, sunflower, rapeseed, corn, tomato, sugar beets, potato, lettuce, cabbage, cucumber, asparagus, carrot, peas, celery, alfalfa, tobacco, walnut?	What is fresh produce?
What is a large-scale sewage purification system?	What are soil salinity, drought, cold, heat, alkaline earth metals, anaerobic (lacking air) conditions?	What is the Sahel region of Africa?	What are herbicide-resistant varieties?	What is education?

• Steps/Key Points •
Problem-Solving Technique

Define the Problem

What are some of the career opportunities in agricultural biotechnology? What are the educational requirements, skills needed, and nature of the work? Develop a short job description for your selected career.

What to Do (Steps)	How to Do It (Key Points)

Decision/Recommendation

There are many areas from which to select a career. Some of them are:

Research & Development – molecular biologists, biochemists, chemists, microbiologists, chemical engineers, laboratory technicians, computer scientists, and others.
Business/Finance/Communications – financial specialists, accountants, marketing and sales personnel, office workers, and others.
Production of Food and Fiber – farmers, brewers, machinery operators, construction workers, welders, control technicians, engineers, electricians, plumbers, packers, delivery drivers, quality control specialists, and others.
Regulatory – registration personnel in research, quality control personnel in production, government regulators, and others.

As you can see, job opportunities related to biotechnology are not all scientific in nature. Someone is needed to build the factories, run the offices, work the computers, make and repair the fermentors, and transport raw materials to the site and products to the consumer.

• **Situation-to-Be-Improved** •
Problem-Solving Technique

Define the Problem

As a committee member on a government task force to determine the fate of genetically engineered organisms, you have been asked by a biotechnology company for permission to test a new strain of bacteria which, when sprayed on a cereal crop, will triple the current yield. In addition, the bacteria are so environmentally "friendly" that they make the cropland pest-free without the use of chemical pesticides.

Preliminary data supplied by the company, however, indicate that there may be a 1 in 1,000,000 chance that this strain of bacteria could mutate and contaminate the soil so that any crop grown in it would be unfit for human or animal consumption for 5 years.

What additional information would you require from the company before you make your decision? What factors would impact your decision, and what weight would you give to each of the factors? What are the benefits? What are the risks?

Would your decision be the same or different if the crops were located in Africa and you knew that triple yields could save millions of people from certain starvation?

Characteristics to Be Considered	What	Why	Current Situation	Recommendations

Decision/Recommendation

Generally, concerns about genetically engineered organisms focus on the following:

- ○ possible "escape" of a genetically engineered organism, so that it invades new ecological niches or outcompetes naturally-occurring organisms, becoming a pest
- ○ possible disruption of a delicately-balanced ecosystem
- ○ possible risks to humans or wildlife
- ○ possible problems of gene stability and gene transfer to unintended recipient organisms
- ○ possible impact on evolution
- ○ the sheer "newness" of the technique

The particular problem addressed here involves microorganisms, which tend to elicit more concern on the part of the public than do plants. Microorganisms are invisible and relatively "unknowable." The framework for evaluating risk in this case could be focused on the following questions:

1. Are we familiar with the properties of the organism and the environment into which it may be introduced?
2. Can we confine or control the organism effectively?
3. What are the probable effects on the environment if the introduced organism or a genetic trait persists longer than intended or spreads to non-target environments?

In order to evaluate the company's request, a strategy for risk assessment should be presented. Has the company developed a profile of the new bacteria's behavior under different environmental conditions? If this is the first time that the company has approached the regulators for permission to test this organism, students may want to recommend a small-scale introduction for field testing with proper containment procedures. If all goes well, levels of containment can gradually be lowered as data on safety are obtained. Multiple-site field testing of the improved strains would be the next logical step towards large-scale testing and commercialization.

• Possibilities - Factors •
Problem-Solving Technique

Define the Problem

A strong agricultural economy is critical to the health of the U.S. economy. The industry accounts for 15% of the gross domestic product and is a key export earner, with foreign sales approaching $40 billion annually. Agriculture and its related industries provide jobs for 21 million Americans.

The development of agricultural biotechnology comes at a critical juncture for U.S. agriculture. Competition for world markets is becoming fierce. At the same time, U.S. producers and processors must meet the challenge of new environmental policies. What are some of the factors that may be realized through plant biotechnology? What are the long-term possibilities for each?

Factors to Consider	Possibilities (Possible Solutions)			

Decision/Recommendation

Some of the factors that may be realized through plant biotechnology are the following:

- improved agricultural products resulting in higher-quality food and fiber
- new agricultural products
- higher crop yields from newly-developed plant strains with greater tolerance to environmental hazards and stress. (Research is being done on ways to harden plants against adverse environmental conditions such as soil salinity, drought, frost, alkaline earth metals, and anaerobic soil conditions as well as viruses and insects.)
- better ecological management of agriculture systems, including maintaining soil productivity and improving water management
- safer and more convenient food products resulting from new techniques for detecting the presence of harmful materials and contaminants; also, better processing methods
- more effective pest-control agents - biopesticides and biofertilizers. (These include bacteria that make herbicide and insecticide compounds act as natural pesticides, and crops that are more self-sufficient in obtaining nitrogen.)
- new food industries like aquaculture (raising fish as a food source), which already produces over 600 million pounds of edible protein annually.

• Forked Road •
Problem-Solving Technique

Define the Problem

Biotechnology is focused not only on pest and disease control, but also on improving the nutritional value and flavor of food.

From a consumer's point of view, what five factors are important to you when selecting popcorn? Which one would you attempt to improve on using biotechnology? Why?

Here are some interesting facts about popcorn:

Americans consume 16.5 billion quarts of popped popcorn annually. About [illegible] of it is eaten outside the home – in theaters, ballparks, schools, etc. One [illegible] of unbuttered, air-popped popcorn provides 1.3 grams of dietary fiber and about 27 calories. If lightly buttered, the calorie count may rise to 126. Popcorn has more protein, phosphorus and iron than do potato chips, ice cream, pretzels or soda crackers. Popcorn pops because heat builds steam pressure inside the seed – most effectively at 13.5 to 14 percent moisture. Archaeologists have found ears of popcorn in New Mexico which, according to radioactive carbon tests, are nearly 5600 years old.

Factors to Consider	Choices	
	Choice One	Choice Two

Decision/Recommendation

You may want to pass out small samples of popcorn to set the stage for this question.

Important factors include "popability," color, taste, nutritional value, texture, crunchiness, smoothness (no insect damage), and others.

• Effect-Cause •

Problem-Solving Technique

Define the Problem

In the area of agricultural biotechnology, you have been awarded a grant from the Alternative Agriculture Foundation either to develop a new crop or to improve an existing one. Where would you focus your efforts? Why? Some of the areas you might consider are environmental preservation, nutritional value, yield, and land use.

Possible Causes	Related Facts	Accept/Reject Cause

Decision/Recommendation

For environmental preservation, students may want to concentrate on developing pest- and disease-resistant crops, nitrogen-fixing characteristics, and drought- and temperature-resistant species.

For nutritional value, students may want to concentrate on increasing protein value and improving fiber content, digestibility, and palatability.

For yields, students may want to focus on increased food volume, harvestability and economics.

For land use, students may want to develop crops that can be grown in the desert, at high elevations, or in a very wet or cold environment. They may concentrate their efforts on developing crops that are more efficient and crops that can be grown in closely-spaced rows.

Does danger lurk in genetically altered crops?

Offering food for thought

By Donna Shaw
INQUIRER STAFF WRITER

HERNDON, Va. — Picture, if you will, two platefuls of food. One is laden with bacon, eggs and hashed brown potatoes. The other holds a genetically engineered tomato developed by Calgene Inc., a California biotechnology firm.

Which plate offers the products most thoroughly evaluated by the U.S. Food and Drug Administration?

If your vote is for the bacon-and-egg combo, think again.

Never mind that bacon is full of fat and chemicals and that eggs contain cholesterol. With few exceptions — potatoes, for one, because they contain a natural toxin — the foods in your grocery store haven't been FDA-tested for safety or nutritional value. Instead, their merits have been established by years, sometimes centuries, of consumption.

Calgene's "Flavr Savr" tomato, on the other hand, is one of the most scrutinized foods in history. A decade of testing, costing $25 million, has pinpointed its contents down to the molecular level. Its unique characteristic is that the effects of one gene, governing rot, have been slowed, allowing the tomato to ripen on the vine.

Last week, with the Flavr Savr on the brink of becoming the first genetically engineered whole food to receive FDA approval, the agency asked its food advisory committee — a panel of independent experts — to determine whether the government was asking the right questions about these high-tech wonders.

Indirectly, the FDA also challenged Americans to really think about the foods they eat. With more than 40 other genetically altered food crops being developed, the meals of tomorrow are likely to contain combinations never before found on anybody's plate.

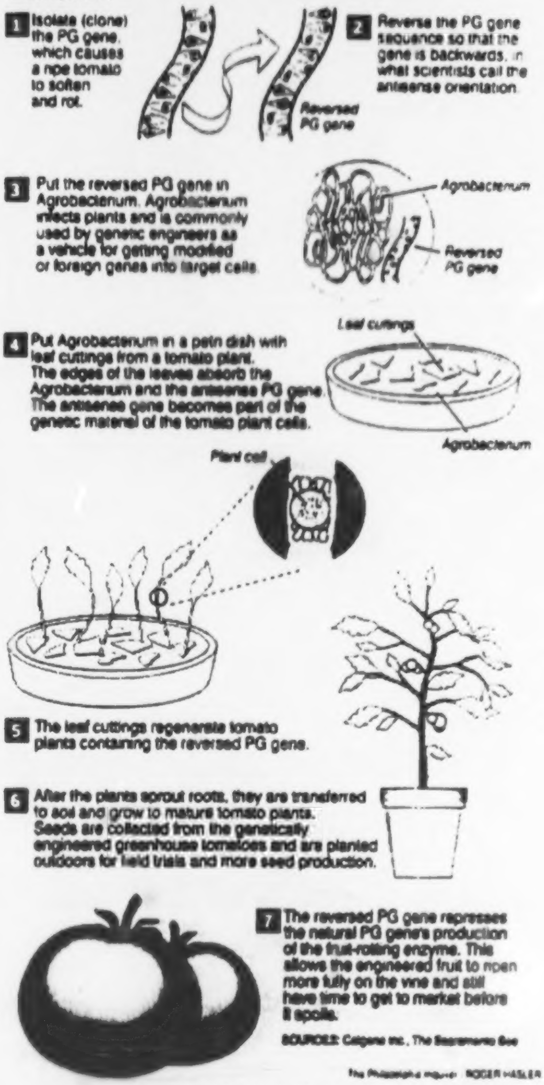
Among the experimental crops are those designed to resist pests, disease, herbicides, cold and drought.

"The bottom line is that the new foods must be as safe as the foods in grocery stores today," James H. Maryanski, the FDA's food biotechnology coordinator, told the committee on the first of its three days of meetings here.

Maryanski said his young daughter recently asked if tomatoes with fish genes would have scales. A tomato containing a frost-resistant gene from the Arctic flounder is under development by a Calgene competitor, DNA Plant Technology Corp., of Cinnaminson.

Genetically Engineered Tomatoes

Ripe tomatoes contain an enzyme called PG (polygalacturonase), which causes the fruit to soften and rot. Genetic engineers at Calgene Inc., in California, have managed to repress production of the PG enzyme by turning around the gene responsible and extending the life of the ripe fruit.



1 Isolate (clone) the PG gene, which causes a ripe tomato to soften and rot.

2 Reverse the PG gene sequence so that the gene is backwards, in what scientists call the antisense orientation.

3 Put the reversed PG gene in Agrobacterium. Agrobacterium infects plants and is commonly used by genetic engineers as a vehicle for getting modified or foreign genes into target cells.

4 Put Agrobacterium in a petri dish with leaf cuttings from a tomato plant. The edges of the leaves absorb the Agrobacterium and the antisense PG gene. The antisense gene becomes part of the genetic material of the tomato plant cells.

5 The leaf cuttings regenerate tomato plants containing the reversed PG gene.

6 After the plants sprout roots, they are transferred to soil and grow to mature tomato plants. Seeds are collected from the genetically engineered greenhouse tomatoes and are planted outdoors for field trials and more seed production.

7 The reversed PG gene represses the natural PG gene's production of the fruit-rotting enzyme. This allows the engineered fruit to ripen more fully on the vine and still have time to get to market before it spoils.

SOURCES: Calgene Inc., The Sacramento Bee

The Philadelphia Inquirer ROGER HASLER

The FDA is developing a policy requiring companies to notify the agency before introducing biotech-enhanced foods, Maryanski said. The FDA also is likely to require some labeling, especially for products containing potential allergens, such as peanuts.

When the meetings ended Friday, the panel took no vote. But the group — made up of biologists, nutritionists and others — generally agreed with the FDA's conclusion that Calgene's tomato was safe and ready for the market.

But, the members said, most subsequent biotech products should be evaluated case-by-case, at least until the body of knowledge on genetically engineered foods is sufficiently expanded.

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Biotech proponents balk at harsher regulation for their products, painstakingly developed with isolated genetic traits. Traditional cross-breeding, they note, can result in unknown and unintended genetic changes, some of which may increase natural toxins or allergens, or reduce vitamins.

They say they are being penalized for their advanced molecular technology, which allows closer scrutiny of food ingredients, and ask why traditional growers aren't held to the same time- and money-consuming standards.

The industry says, too, that the public needs to be better educated about science. DNA, the genetic material found in every living organism, is consumed with every fruit, vegetable and meat. Yet no one turns green from eating spinach or sprouts fins after eating fish.

On Friday, representatives of groups that include the Union of Concerned Scientists, the Environmental Defense Fund and Consumers Union said that while Calgene had been more than cooperative in providing documentation, other compa-

See TOMATO on E2

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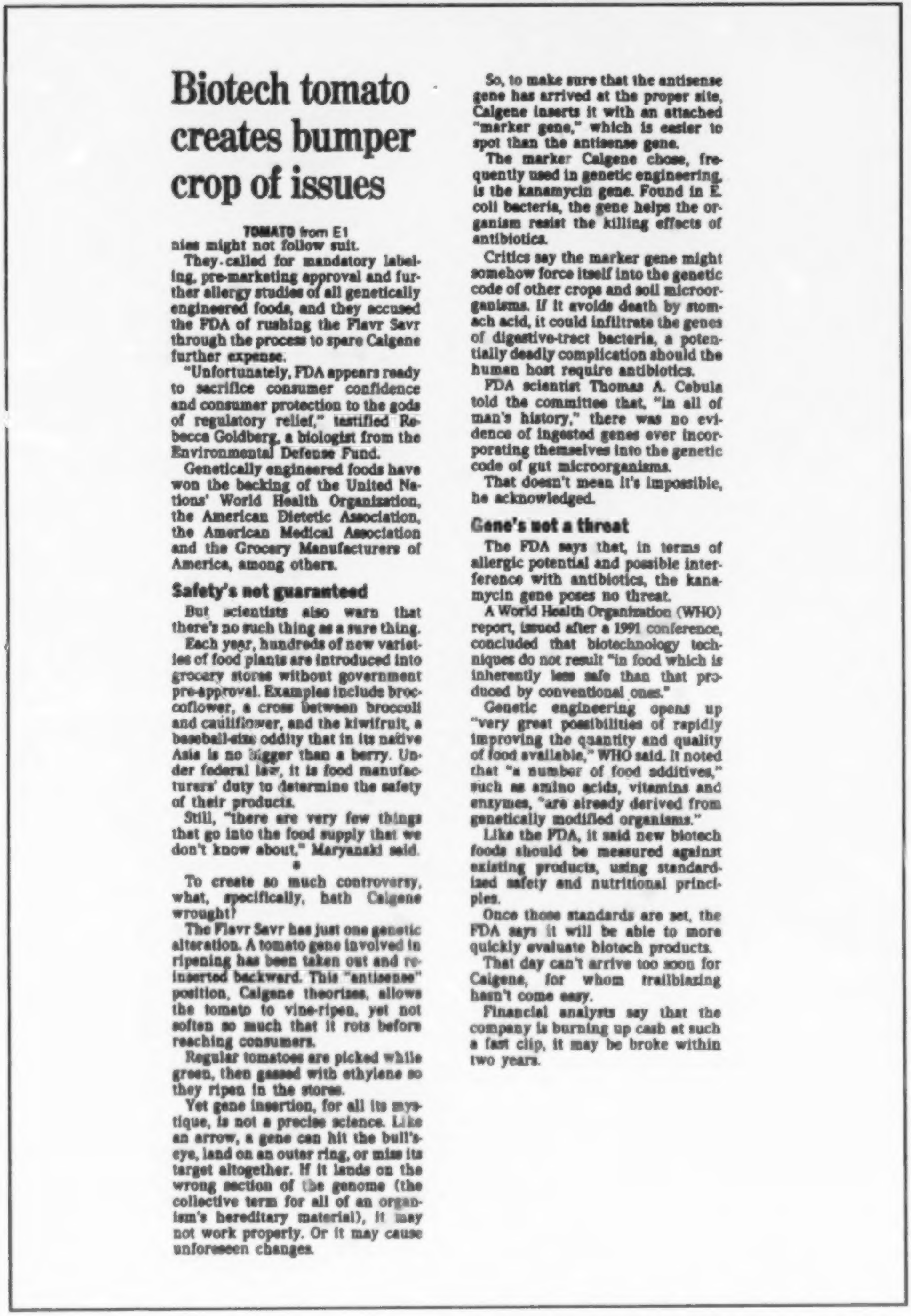

Biotech tomato creates bumper crop of issues

TOMATO from E1

nies might not follow suit.

They called for mandatory labeling, pre-marketing approval and further allergy studies of all genetically engineered foods, and they accused the FDA of rushing the Flavr Savr through the process to spare Calgene further expense.

"Unfortunately, FDA appears ready to sacrifice consumer confidence and consumer protection to the gods of regulatory relief," testified Rebecca Goldberg, a biologist from the Environmental Defense Fund.

Genetically engineered foods have won the backing of the United Nations' World Health Organization, the American Dietetic Association, the American Medical Association and the Grocery Manufacturers of America, among others.

Safety's not guaranteed

But scientists also warn that there's no such thing as a sure thing.

Each year, hundreds of new varieties of food plants are introduced into grocery stores without government pre-approval. Examples include broccoflower, a cross between broccoli and cauliflower, and the kiwifruit, a baseball-size oddity that in its native Asia is no bigger than a berry. Under federal law, it is food manufacturers' duty to determine the safety of their products.

Still, "there are very few things that go into the food supply that we don't know about," Maryanski said.

▪

To create so much controversy, what, specifically, hath Calgene wrought?

The Flavr Savr has just one genetic alteration. A tomato gene involved in ripening has been taken out and reinserted backward. This "antisense" position, Calgene theorizes, allows the tomato to vine-ripen, yet not soften so much that it rots before reaching consumers.

Regular tomatoes are picked while green, then gassed with ethylene so they ripen in the stores.

Yet gene insertion, for all its mystique, is not a precise science. Like an arrow, a gene can hit the bull's-eye, land on an outer ring, or miss its target altogether. If it lands on the wrong section of the genome (the collective term for all of an organism's hereditary material), it may not work properly. Or it may cause unforeseen changes.

So, to make sure that the antisense gene has arrived at the proper site, Calgene inserts it with an attached "marker gene," which is easier to spot than the antisense gene.

The marker Calgene chose, frequently used in genetic engineering, is the kanamycin gene. Found in E. coli bacteria, the gene helps the organism resist the killing effects of antibiotics.

Critics say the marker gene might somehow force itself into the genetic code of other crops and soil microorganisms. If it avoids death by stomach acid, it could infiltrate the genes of digestive-tract bacteria, a potentially deadly complication should the human host require antibiotics.

FDA scientist Thomas A. Cebula told the committee that, "in all of man's history," there was no evidence of ingested genes ever incorporating themselves into the genetic code of gut microorganisms.

That doesn't mean it's impossible, he acknowledged.

Gene's not a threat

The FDA says that, in terms of allergic potential and possible interference with antibiotics, the kanamycin gene poses no threat.

A World Health Organization (WHO) report, issued after a 1991 conference, concluded that biotechnology techniques do not result "in food which is inherently less safe than that produced by conventional ones."

Genetic engineering opens up "very great possibilities of rapidly improving the quantity and quality of food available," WHO said. It noted that "a number of food additives," such as amino acids, vitamins and enzymes, "are already derived from genetically modified organisms."

Like the FDA, it said new biotech foods should be measured against existing products, using standardized safety and nutritional principles.

Once those standards are set, the FDA says it will be able to more quickly evaluate biotech products.

That day can't arrive too soon for Calgene, for whom trailblazing hasn't come easy.

Financial analysts say that the company is burning up cash at such a fast clip, it may be broke within two years.

Article from *The Philadelphia Inquirer,* 4/10/94

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Program: **Common Ground: Agriculture for a Sustainable Future**
Unit 4: **Third World Impact and Global Stability**

Economic importance and interdependency of agriculture throughout the world

Competency/Terminal Performance Objective

Evaluate the economic importance of global agriculture through imports and exports and recognize the complexity of agricultural interdependency.

Competency Builders/Pupil (Learner) Performance Objectives

Assess the interdependency of agriculture on a global basis.

Describe and demonstrate examples of agricultural trade, import and export commodities and balances, and food security issues.

Predict future agricultural trends based on current and historical data.

Create a data chart to organize agricultural data by country, crop, imports, exports, and % of gross domestic product (GDP).

Describe and discuss the economic impact of the agricultural sector on national economies.

List five international government agencies that influence and affect agriculture around the world.

Identify agricultural production practices used in various parts of the world.

Applied Academics Competencies

Communications
History
Mathematics
Science

Equipment, Supplies, References, and Other Resources

Activity #1 - Ag Around the World: Crops, Production Practices, Imports/Exports

- computer databases (optional)

Activity #2 - Agricultural Importing and Exporting

- newspaper *(Wall Street Journal* or *New York Times)* to obtain currency exchange rates

Activity #3 - The Domino Effect

- 50 dominoes
- 50 labels

Activity #4 - Jeopardy!-like Game

1. scissors
2. felt-tipped marker
3. Velcro dots or tape
4. 2 large poster boards (same size)
5. 2 buzzers or bells

REFERENCES/RESOURCES

U.S. Agriculture in a Global Economy–1985 Yearbook of Agriculture,
U.S. Government Printing Office,
Washington, DC
0-484-628: QL 2, LC 85-600627

Activities to Enhance Student Understanding of International Agriculture – available from Ohio Agricultural Education Curriculum Materials Service, 254 Agricultural Administration Bldg., The Ohio State University, 2120 Fyffe Road, Columbus, OH 43210-1067

Situation

These activities are designed for students in grades 9-12.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
This activity will give students an opportunity to investigate and summarize agricultural data for five countries around the world – Canada, Japan, Mexico, United Kingdom, and United States – and one economic unit – Commonwealth of Independent States (CIS).	**ACTIVITY 1** *Ag Around the World: Crops, Production Practices, Imports/Exports* **Interest Approach** Each day exported products are shipped worldwide, and imported products arrive at the borders of countries throughout the world. Climate, soil, land availability, irrigation, government policies, technology, local economies, taxes, tariffs, and culture all impact the crops that countries grow and export. These factors also determine which products are more economical to import and which are impossible to produce domestically. This exercise provides a look at a small group of countries as well as the independent states formerly of the Soviet Union. It shows how agriculture supplements their national economy.
See page 7.	**Teaching Procedure** Divide the class into six groups. Assign a country or economic unit to each group. Have the groups research their assigned country to determine crops grown, production practices, agricultural items exported (along with volume and $ value), agricultural items imported (along with volume and $ value), and agriculture as a percent of gross domestic product (GDP). Each group should collect their data in the format given on page 7.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
The purpose of this activity is to develop an understanding of world trade by simulating export activities of specific agricultural products with several countries. Have students check a current edition of the *Wall Street Journal* or *New York Times* to locate currency exchange rates. Then have them calculate the price for each agricultural item in various currencies.	**ACTIVITY 2** *Agricultural Importing and Exporting* **Interest Approach** The U.S. is the largest exporter of agricultural products in the world. The production from approximately one out of every 2.5 acres of cropland is exported. U.S. farm exports generate income that spreads throughout the national economy. More than one million people in the U.S. work in agricultural export-related jobs. The U.S. is also one of the largest importers of agricultural products in the world. Every time American consumers drink a cup of coffee or a glass of iced tea; eat a banana split or a chocolate candy bar; add vanilla, cinnamon, or pepper to their food; wear silk clothing; or buy rubber tires, they are benefiting from agricultural trade. These and many other agricultural products consumed in the U.S. are produced in other countries.
See pages 8-9.	**Teaching Procedure** Divide the class into groups of 4 to 6 students. Have one student in each group represent the U.S. and the other students represent one each of the assigned countries. Assign the countries to each group according to the number of students in the group. With the one U.S. representative, assign 3 countries to a 4-student group, 5 countries to a 6-student group, and so on. If there are a few more students than comprise a full group, assign them a particular country to work on as a team.

Directions for the Teacher	Teaching Procedures: Interest Approach/Teaching Methods
This exercise provides a visual example of the impact of interrelationships and interdependencies found throughout the world in agriculture. It provides students with a picture of the complexities involved when a new law or policy is enacted or an existing one is changed.	**ACTIVITY 3** *The Domino Effect* **Interest Approach** So many things in the U.S. and throughout the world are interrelated that when a decision is made to change an existing system or implement a new one, many people, businesses, and other concerns are affected by the change. Often the interrelationships are not fully understood or examined when a policy is changed or implemented. Provide students with some relatively recent examples, such as the luxury tax and its repeal, and passage of Proposition 187 in California against providing education and social services to illegal immigrants. In both cases, the unilateral decisions made had enormous impact on the economic and social structures. **Teaching Procedure** In order to visualize the complexities in making a policy change, let's use as an example the current U.S. government subsidy program. As a prominent legislator, you are able to obtain enough votes to eliminate the current government subsidy program. Make a list of all the people, businesses and other concerns that will be affected by this change. Write one effect on each of the labels and stick one label on each domino. Label one domino with the change in policy, "Elimination of agricultural subsidy program," and set it up first, on end. Set up the rest of the dominoes in a pattern (such as branches of a tree) grouped by similarities (such as economic, social, health/safety, political, etc.). When all the dominoes have been set up, start the action by knocking over the "policy" domino. Watch the effect on all the others.

Directions for the Teacher

If the *Jeopardy!*-like board was already constructed in Unit 1, Activity #1, skip the advance preparation procedures and insert the category/answer template located on pages 10-11 in this unit.

Advance Preparation

Prepare the *Jeopardy!* board by cutting 30 3x5-inch windows spaced one inch apart for game categories and answers. Save the cutout windows to serve as flap covers for the answer portions. There will be 5 windows across the top for categories and an additional 5 windows below each of these for answers. Answers for each category will be designated point values of 10, 20, 30, 40 and 50. Attach the second poster board to the first with Velcro dots or tape. Tape together the answer sheets provided and slide between the two poster boards. Reattach the flaps over the answers by taping each across the top to serve as a hinge. Use the marking pen to designate point value on each of the answer flaps.

Teaching Procedures: Interest Approach/Teaching Methods

ACTIVITY 4

Jeopardy!-like Game

Interest Approach

The growth in agricultural trade has given us a global food and agricultural system for the first time in history. Among other things, this system has greatly increased food security for the world as a whole, since it makes food available on demand through trade. As a consequence, there have been no major famines in the post-World War II period except 1) where national governments did not want the world to know about them; 2) where the problem was so slow to be acknowledged that logistic problems made it impossible to respond in sufficient time (as in Africa); or 3) both.

Teaching Procedure

Playing the game: Divide the students into 2 or 3 groups. Provide the person at the head of each line with the buzzer or bell. Flip a coin to determine which group makes the first selection. Open the flap selected to expose the answer. The first person to ring the buzzer gets to respond by providing a question for the revealed answer. (**Note:** In many cases, there may be more than one correct question to a given answer.) The first person with the correct question scores the value on the flap. A wrong question results in a deduction of the value on the flap. When all flaps are exposed, the highest score wins!

Agriculture Around the World: Crops, Production Practices, Imports/Exports

PART 1 COUNTRY ______________________

Crops Grown **Production Practices**

Agricultural Exports	Volume	Value

Agricultural Imports	Volume	Value

Agriculture as % of GDP ______________

Assign a student to summarize the findings of each group in data chart format similar to this:

Country/ Economic Unit	Crops Grown	Production Practices	Agricultural EXPORTS	Volume	Value	Agricultural IMPORTS	Volume	Value	Ag. as % GDP
Canada									
CIS									
Japan									
Mexico									
United Kingdom									
United States									

Questions

Of the countries studied, which ones are major exporters of wheat? cotton? corn?
Which ones are major importers of wheat? cotton? corn?

How many agricultural products on your list are value-added exports; i.e., products that undergo some processing or are unprocessed but relatively expensive per unit because of high transportation or storage costs? Examples are polished rice, corn gluten feed, animal foodstuffs, wheat flour, oilseed products, processed cotton, tobacco and seed products, horticultural and tropical products. It is estimated that over 40% of the more than one million jobs in the U.S. related to exports involve value-added products.

In the U.S., exports of raw products add $1.13 per export dollar in economic activity. Value-added products add $1.68 per export dollar. What percent increase over raw products do value-added products generate?

Agriculture Around the World: Crops, Production Practices, Imports/Exports

PART 2

Country (or Economic Unit)	Monetary Unit	Imported Crops
Canada	dollar	soybeans, corn, cotton, oranges
CIS	ruble	corn, wheat, soybeans
Japan	yen	wheat, rice, cotton, soybeans
Mexico	new peso	corn, wheat, soybeans, lettuce
United Kingdom	pound sterling	corn, wheat, cotton, tomatoes

What are the lowest common units for U.S. exports for the above crops? (i.e., pounds, bushels, cartons, etc.) First have the class discuss what they think the common units of measure are for each of the above crops.

You may want to let the students research prevailing prices for the commodities at their local library. The following price list could also be used.

Crop	Unit	Price/Unit (U.S. Dollars)
Soybeans	bushel	$ 6.45
Corn	bushel	2.55
Cotton	pound	.72
Wheat	bushel	3.20
Rice	per 100 lb (cwt)	8.50
Oranges	per 38 lb	10.00
Lettuce	per crate of 24 heads (50 lb)	8.00
Tomatoes	25 lb cartons	5.00

Have the students representing the U.S. in each group "sell" a specified number of units (provided by the teacher) of the designated crops to each of the other countries represented by the other students in the group. Each of the students will need to calculate the proper amount of money in his/her country's currency (according to exchange rates) to pay for each of the crops, as well as a total per country. The student representing the U.S. should "collect" the money and convert the totals for each country back to U.S. dollars.

What happens if the U.S. dollar strengthens by 3%? Who benefits?

Extension: Have the students research export crops for each of the countries listed. Have them reverse the procedure, selling those crops to the U.S.

Agriculture Around the World: Crops, Production Practices, Imports/Exports

Sample answers:

U.S. sells soybeans, corn, cotton and oranges to Canada:

Crop	# Units	Value/Unit	Total Price U.S. $	Conversion Rate (Currency per U.S. $)	Canadian Dollars
soybeans	140	6.45	903.00	1.37	1237.11
corn	80	2.55	204.00	1.37	279.48
cotton	400	.65	260.00	1.37	356.20
oranges	25	10.00	250.00	1.37	342.50
TOTAL			1617.00		2215.29

U.S. sells corn, wheat, soybeans to CIS:

Crop	# Units	Value/Unit	Total Price U.S. $	Conversion Rate (Currency per U.S. $)	CIS Rubles
corn	20	2.55	51.00	2153	109,803.00
wheat	10	3.20	32.00	2153	68,896.00
soybeans	50	6.45	322.50	2153	694,342.50
TOTAL			405.50		873,041.50

U.S. sells wheat, rice, cotton, soybeans to Japan:

Crop	# Units	Value/Unit	Total Price U.S. $	Conversion Rate (Currency per U.S. $)	Japanese Yen
wheat	25	3.20	80.00	99.8	7,984.00
rice	100	8.50	850.00	99.8	84,830.00
cotton	400	.65	260.00	99.8	25,948.00
soybeans	60	6.45	387.00	99.8	38,622.60
TOTAL			1577.00		157,384.60

U.S. sells corn, wheat, soybeans, lettuce to Mexico:

Crop	# Units	Value/Unit	Total Price U.S. $	Conversion Rate (Currency per U.S. $)	Mexican New Peso
corn	60	2.55	153.00	3.35	512.55
wheat	100	3.20	320.00	3.35	1072.00
soybeans	50	6.45	322.50	3.35	1080.38
lettuce	8	8.00	64.00	3.35	214.40
TOTAL			859.50		2879.33

U.S. sells corn, wheat, cotton, tomatoes to United Kingdom:

Crop	# Units	Value/Unit	Total Price U.S. $	Conversion Rate (Currency per U.S. $)	Pound Sterling
corn	75	2.55	191.25	.65	124.31
wheat	120	3.20	384.00	.65	249.60
cotton	300	.65	195.00	.65	126.75
tomatoes	35	5.00	175.00	.65	113.75
TOTAL			945.25		614.41

If the dollar strengthens by 3%, then 3% more foreign currency would be needed to purchase each of the commodities indicated. When that happens, the U.S. benefits.

JEOPARDY! ANSWERS

Stands for	"You Are What You Eat"	Where in the World	Let's Trade	Crops Worldwide
A United Nations organization called the FAO that strives to improve the technology of agriculture in developed countries.	The category of crops that includes rice, wheat and corn – the most important food source for consumers around the world.	A nation with small crop land compared to its total land size. Only 4% of its land is crop land; 2% is in meadows and pasture.	Two of the many factors that directly influence the future role of world agricultural trade.	More than 62% of the world's production of this crop is in China, the U.S. and the Soviet Republics.
An organization called the WFP that uses food aid to further development in needy countries and provides food in emergencies.	The predominant food grain consumed in the temperate zone.	The country with an average farm size of 429 acres.	The process of sending domestically produced goods to other countries.	The crop that leads the world in vegetable oil production (though palm oil exceeds it in world trade).
A United Nations agency called IFAD that deals with project and program financing, primarily for the poorest developing countries.	The cereal crop consumed throughout Asia.	An area of the world where farms range from 10 acres to a maximum of 170 acres.	The process of bringing in goods or commodities from another country for sale, use or production.	Three of the major importers of wheat.
A group called the WFC that convenes annual meetings of the agricultural ministry from 36 member countries.	Parts of the world where corn is the major cereal crop.	A group of countries that leads the world in production of potatoes, barley, rye, oats, sunflower seed and sugar beets.	Called the GDP, the market value of all goods and services produced by a given country in a given year.	Two of the major exporters of soybeans and soybean products.
An organization called the IMF that is concerned with maintaining stability in world monetary matters.	The principal crop in parts of Africa, Latin America and Oceania, where climate and prevailing rainfall patterns hinder cereal production.	Area of the world that is heavily dependent on favorable monsoons.	Three of the seven major trade regions of the world.	The crop with high nutritional value that comprises about 57% of all feed grain production.

JEOPARDY! QUESTIONS

Stands for	"You Are What You Eat"	Where in the World	Let's Trade	Crops Worldwide
What is the Food and Agriculture Organization?	What are cereal crops?	What is Canada?	What are population growth rate, income growth, changes in dietary preference, and policy changes in producing and trading countries?	What is cotton?
What is the World Food Program?	What is wheat?	What is the U.S.?	What is exporting?	What are soybeans?
What is the International Fund for Agricultural Development?	What is rice?	What is the European Community (EC)?	What is importing?	What are the Commonwealth of Independent States, China, Japan, Egypt, Eastern Europe, the European Community, and Brazil?
What is the World Food Council?	What are Latin America and Africa?	What is the Commonwealth of Independent States?	What is the gross domestic product?	What are U.S., Brazil, Argentina, and the European Community?
What is the International Monetary Fund?	What is cassava?	What is South Asia (Bangladesh, India, Pakistan, Nepal, and Sri Lanka)?	What are the European Community; Africa; the Middle East; the Pacific Rim; South & Central America; U.S., Canada and Mexico; the Commonwealth of Independent States?	What is corn?

• Steps/Key Points •
Problem-Solving Technique

Define the Problem

Global food security – assuring that food is accessible to the world's people – remains an elusive goal. Although world food production over the past two decades has out-paced global growth, a large number of the world's inhabitants remain undernourished. Food security is primarily a concern of poor people and poor nations. At the global level, the primary problem is food distribution. Countries and individuals that lack purchasing power cannot buy the food they need, even when supplies are abundant. Both individually and collectively, many nations have tried to provide food security in a number of ways. What are these ways? What impact might new technology have on them?

What to Do (Steps)	How to Do It (Key Points)

Decision/Recommendation

NATIONAL APPROACHES

Increasing domestic food production - A beneficial, though sometimes costly, way of insuring against trade-related risks – economic (tariffs, trade restrictions, price variability), political (embargoes, export restrictions, policy-related conditions), and logistical (transportation bottlenecks). This approach is also an important element of food security where transportation problems increase the risk and expense of relying on external food supplies. ***How?*** Increased yields, more efficient farming practices, new technologies, instituting policies to encourage domestic food production for specific crops.

Building national food security stocks - Even with increased domestic production, countries must offset production variations to guarantee a stable food supply by 1) accumulating national stocks or 2) relying on international stocks and trade to offset more extreme variations. Since global production is less variable than national or regional production, holding stocks at the national or regional level requires larger reserves than holding them globally.

Advantages: More timely response to changes in production and savings of foreign exchange.
Disadvantages: The expense of holding stocks, especially if storage is prolonged and carrying costs are high.

(continued)

Decision/Recommendation *(continued)*

RELYING ON INTERNATIONAL MARKETS

This alternative to self-sufficiency involves either holding monetary reserves or relying on food aid to supplement regular commercial purchases. These strategies seek to maintain food imports at a level that can be financed without international aid, using trade to improve the diet and to cover national variability in production.

Advantages: Allows a country to specialize in commodities in which it has a competitive advantage; reduces the cost of holding and managing expensive stocks; permits flexibility in responding to changing conditions.
Disadvantages: Economic conditions may prevent access to global food markets; country may end up in weak foreign exchange position due to debt and falling export earnings; food markets are unstable when global food supplies are low and the market becomes volatile.

Food aid - Helps out in severe emergencies or when a country is facing long-term food deficits and has inadequate foreign exchange earnings.

Advantages: A practical short-term approach when needed.
Disadvantages: Difficult to deliver quickly; requires extensive approval process within donor countries; subject to changing political and economic priorities within donor countries, which may affect availability and allocation. Commodity availability generally reflects the surpluses of major donor countries (U.S., EC) and may not match consumption patterns or preferences in recipient countries. Also, food aid tends to be less available when need is greatest – when global supplies are short and prices are high. In the long run, increased food security depends heavily on the pattern of economic development, both within and between nations.

• **Situation-to-Be-Improved** •
Problem-Solving Technique

Define the Problem

Most competitors in the global marketplace need additional skills and knowledge in order to be effective. There is a multitude of new opportunities that present themselves as many countries strengthen their economies, increase their personal income levels, and move into the consumer marketplace. What interdisciplinary skills and knowledge are necessary in order to work in careers which are global in nature? How would you propose to acquire them? Provide an action plan outlining the steps that you would need to take. Be creative in your approach.

Characteristics to Be Considered	What	Why	Current Situation	Recommendations

Decision/Recommendation

Student action plans may range from developing knowledge through formal study (courses in business, language, psychology, etc.) to informal approaches such as immersion in culture or language by living and working with an international family, business, or government overseas. Individual reading, computer discussion groups, and making use of the Small Business Association and associated international agencies may be some of the areas addressed in the action plans.

Interdisciplinary skills will be essential in order to deal effectively with different customs, languages, cultural practices, internal and external policies, and government structures. A background in sociology, psychology, communications, history and business will be very helpful.

• Possibilities - Factors •
Problem-Solving Technique

Define the Problem

The U.S. is still competitive in world markets for most of its agricultural and forest exports, but its future position and comparative advantage are in question. To retain its competitive position, what are some of the factors/problems that need to be considered in the future? What are possible solutions for each?

Factors to Consider	Possibilities (Possible Solutions)			

Decision/Recommendation

Comparative advantage is affected by investments in human and natural resources and in research and development of technology as well as by policy, marketing, and the transportation system. It is critical for the future of U.S. agriculture to understand the interactions and trends of these variables and to act on that knowledge.

To meet these challenges, the agricultural science and education system must attract and train scientists and specialists with skills in molecular genetics, human nutrition, soil and water sciences, international marketing, systems analysis, agricultural engineering, and other specialized fields.

Improved resource-saving technologies need to be incorporated into current production practices. The American farmer's strategy must be to invest only in things that will significantly lower per-unit costs. This often means output-increasing technology. The competitive advantage of U.S. farming today and in the future lies less in its land and climate than ever before.

New markets, rising from population increases in middle-income countries with good economic growth rates, will provide avenues of opportunity for new and existing farm products.

• Forked Road •

Problem-Solving Technique

Define the Problem

Your company, Biotech Solutions, Inc., has developed a new crop with the following characteristics:

- higher nutritional value than corn or rice
- pest and drought resistance
- potential for significant yield increase

Your job is to market the seed from this product internationally to Mexico and China. First, create a name and a logo for your new product. Then create a marketing plan to ensure that the crop is grown on 18% of the farmland in those countries by the end of the third year of introduction. In developing your plan, consider trade policies (tariffs, agreements, etc.), economics (transportation, communications, etc.), cultural differences (language, customs, internal policies), and crop patent protection (so that the seed can't be saved and sold within that country, eliminating your future sales). Compare each of these areas for Mexico and China. After you have made your comparison, decide which country would be your first choice for marketing this new crop. Justify your answer.

Factors to Consider	Choices	
	Choice One	Choice Two

Decision/Recommendation

Students may choose to address some or all of the following areas in each country: international selling strategies, marketing strategies, culture & customs, and agricultural practices. They may also propose some strategies of their own. Part of their plan might include education (of government personnel and farmers). Students should take current and future trade agreements into consideration in their plans; for example, the North American Free Trade Agreement (NAFTA) and the General Agreement of Tariffs and Trade (GATT).

• Effect-Cause •

Problem-Solving Technique

Define the Problem

On January 1, 1994, the North American Free Trade Agreement (NAFTA) went into effect. NAFTA's main achievement is including Mexico in the economic mainstream of North America. What are the implications of NAFTA in trading agricultural products between Mexico, the U.S. and Canada?

Possible Causes	Related Facts	Accept/Reject Cause

Decision/Recommendation

Even before NAFTA, the U.S. and Canada have had a free trade agreement since 1988. The main difference since NAFTA is the addition of Mexico. As Mexico becomes more industrialized and modernized, using the new opportunities for trade, its demand for foreign products can be expected to increase. Competitively, the U.S. is more likely to serve Mexican consumers, and Mexican agriculture is likely to be capitalized by American investment. For some crops, the U.S. will be facing more competition. But where the U.S. has a strong export presence, it should continue to do well.

Agricultural efficiency will be the key factor. For example, in California and Arizona agriculture is practiced very efficiently. That will be a definite advantage for the U.S. under free trade. California agriculture can effectively compete in the Mexican market even against Mexican products. For example, the U.S. can sell fresh tomatoes in Mexico even though Mexico is a leading exporter of tomatoes.

Another key element is the change in the **ejido** (communal farm) system which has dominated Mexican agriculture in the past. These farms are now dismantled. The land is opened up for investment opportunities for the U.S. in Mexican agriculture. Before NAFTA, this was impossible.